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AMERICAN ISTHMIAN CANAL ROUTES.

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[*A Lecture delivered before the* FRANKLIN INSTITUTE, *November 4, 1889.*]

Admiral AMMEN was introduced by Prof. COLEMAN SELLERS, of the INSTITUTE, and spoke as follows:

MEMBERS OF THE FRANKLIN INSTITUTE AND LADIES AND GENTLEMEN:

Forty-eight years ago I was under instruction in the Naval School, in Philadelphia, which, two years later, was removed to Annapolis, and has grown into an institution worthy of the nation, aided in its infancy by the genius of Professor Chauvenet, your townsman, who instructed the midshipmen, of whom I was one.

More than a quarter of a century ago I left your port in command of the monitor *Patapsco* to take part in the bombardment of Fort Sumter. During the Civil War and after-

wards I had found many valued friends in this city. Among those I prized most highly was the late John Welsh, whose memory is so highly honored in the community, where he lived so long and usefully. In all these years I have approached Philadelphia from whatever direction with a feeling of satisfaction; there is no squalidity in its outskirts, there is none along its centres, so disagreeable a feature in neighboring cities. It seems that everybody here has a comfortable home and a useful existence, and this condition is gratifying to every one who has the instinct of humanity.

Regarding your city with so much appreciation, I was gratified to receive an invitation to deliver a lecture before this INSTITUTE, that in the past, as in the present, is recognized as one of the sources through which Philadelphia has attained such practical results in advancing the common interests of mankind, through science ministering to the necessities that belong to men. I, however, regarded the invitation rather as an acknowledgment of my efforts in obtaining information relating to the question of American Isthmian Transit than that I could be expected to say much that was not already known to the members of the INSTITUTE.

Your citizens generally know that Mr. Charles Biddle, of Philadelphia, was sent to Panama, in Central America, in May, 1835, appointed by President Jackson under a Congressional resolution that explains the earnest interest felt at that time in the consideration of an Isthmian canal and upon what political basis it should be constructed. The resolution reads as follows:

"*Resolved*, That the President of the United States be respectfully requested to consider the expediency of opening negotiations with the governments of other nations, and particularly with the governments of Central America and New Granada, for the purpose of effectually protecting, by suitable treaty stipulations with them, such individuals or companies as may undertake to open a communication between the Atlantic and Pacific Oceans by the construction of a ship canal across the isthmus which connects

North and South America; and of further securing forever, by such stipulations, the free and equal right of navigation of such canal to all nations, on the payment of such reasonable tolls as may be established to compensate the capitalists who may be engaged in such undertaking and complete the work."

In compliance with that resolution, President Jackson appointed, May 1, 1835, Mr. Charles Biddle, of Philadelphia, a special agent, to proceed to the isthmus, for the purpose of making all necessary inquiries in reference to the work. Mr. Forsyth's letter of instructions directed him to proceed by the most direct route to the port of San Juan, Nicaragua, and ascending that river, cross thence to the Pacific, making all inquiries as to plans, surveys and estimates, and procuring at Guatemala copies of all public documents regarding the subject. From Guatemala he was to proceed to Panama, make as thorough an examination as possible of the route there, and at Bogota obtain copies of public documents in reference to a projected railroad, and especially any information in relation to a concession said to have been made by the government of New Granada to a certain Baron Thierry.

Furnished with a circular letter to all the United States consuls in the countries referred to, and also in Mexico, Mr. Biddle set out on his journey, but, as it appears from the difficulties of obtaining at that time direct conveyance to San Juan, Mr. Biddle went to Panama, never reached Nicaragua, and died soon after his return to the United States, in 1836, without making any full report.

It appears, therefore, that more than half a century ago, when our territory and material interests on the west coast were prospectively insignificant as compared to their present extension and importance, our statesmen of that day, without distinction of party, regarded them sufficient to warrant the above action, and a distinguished citizen of your city was designated to carry the resolution into effect. He died fifty-three years ago, probably from his detention on the Isthmus of Panama, as pestiferous as any spot on the globe.

It is not my intention to follow this subject historically, I propose to present only a brief sketch of more recent events, relating principally to reliable surveys and their results.

The readers of *Harper's Monthly* of thirty-five years ago may recall an account of an attempted exploration of the Isthmus of Darien, by Lieut. Strain, of the Navy. It was a tragic account of loss of life through starvation in a country teeming with abundance; where one of the lords of the soil, or a hundred of them, would have set out to go from sea to sea, picking their food by the wayside. The forest would have supplied vegetable food of wholesome kinds, it was filled with game too, and the waters abounded in fish. The expedition was one of those sad adventures undertaken without study of what was necessary, not alone for success in establishing topographical facts, but as well for the prevention of misery, and the actual starvation of more than one-half of the party. After reading this narrative, I became much interested from an apparently insignificant circumstance—the supposed hearing of the evening gun of the *Cyane*, the vessel they had left three days before at anchor in Caledonia Bay. Soon after leaving the vessel to make their intended exploration, they began the ascent of a mountain, following up a ravine, and finding that toilsome, they availed themselves of a pathway of the Indians over the hills, and in the afternoon encamped on the Pacific slope. The following morning they went down this slope and soon reached a considerable stream, which they called the Sucubuti, at that point several hundred feet above the sea, as was afterwards known. An ascertainment at that time, with a level, of the height above sea of this flowing water would have effectually barred any belief in the statement that had been made by Cullen and others, as to the low line of levels between the seas higher up on the water-shed than the region they traversed. At that time, that admirable little instrument, the pocket aneroid, was not in use; with such an instrument, no more cumbersome than a watch, in one or two days the absolute falsity of the asserted low gap between the two oceans could have

been established, and further exploration on that line or above on that line of drainage, would have been entirely useless; there could be no low gap between the two seas, as asserted, with a considerable stream lying close to the coast range of mountains, hundreds of feet above the seas.

I wrote to Strain, whom I knew well, calling his attention to the significance of the supposition that they had heard the evening gun of the *Cyane*. Were it so, in my belief, a gap in the mountains would be found through which the sound had come. Months passed before I heard from him; he was then on the Isthmus of Panama, where, not long after, in 1857, he died. He made no reply to my direct question as to hearing the evening gun and expressed the belief that the Isthmus of Darien would furnish no practicable route, which he thought would be found on the Isthmus of Panama, on or near the line of the railroad. Not long after, I was ordered to the *Saranac* and made a cruise in the Pacific: on our arrival at Panama, I was transferred to the flag-ship *Merrimac*, and still interested in the Isthmus, made provisional arrangements to visit in a tug the River Chepo, the mouth of which is some twenty miles east of the city of Panama. The captain of the *Merrimac* did not approve of my personal efforts to explore, and consequently was not willing to grant me leave of absence for a week. My research would have looked to a possible connection with the Gulf of San Blas by means of a tunnel, after locking above the sea level, high enough at least to have a dry foot in making the excavation. This route has yet the unreasoning support of some well-meaning men, who can look only at one side of a question, and cannot consider relative advantages. Even should a sea-level canal be regarded there as practicable, with a tunnel certainly of not less than seven miles in length, and with a mountain overhead of some 5,000 feet in height, such a canal could not compare favorably with the Nicaragua route as now located.

On my return to the United States in the *Merrimac*, in February, 1860, I wrote to the Geographical Society of New York my ideas touching the exploration of the Isthmus, and the method that seemed to me necessary to secure satis-

factory topographical results, namely: to follow up all of the large water-sheds and make a skeleton map, with curves of elevations. These could be readily connected where desired, by lines of levels. These ideas were favorably received by the Society, but we were then absorbed in questions that terminated a few months later in civil war, which for years shut out of the public mind any consideration of Isthmian explorations.

During the early part of 1866, General Grant was on duty in Washington; he and myself had been playmates when children, which sometimes establishes an intimacy and confidence such as nothing else does. I called his attention to how little was known in relation to the Isthmus of Darien proper, where it seemed to me there was a fair prospect of finding favorable conditions for the construction of a canal. He quite agreed with me, and made an examination of an enlargement from an old Spanish map in the Naval Observatory Library. About this time Justice Field, of the Supreme Court, presented to Senator Conness, of California, a resolution, which he offered, calling upon the Superintendent of the Naval Observatory for all information touching Isthmian surveys. The passage of this resolution produced (Senate Ex. Doc. No. 62, 39th Congress, 1st Session, published in 1866) the first compendium of information relating to this subject known to me.

In the autumn of 1867, I was in command of the flagship *Piscataqua*, bound for the Asiatic station. In December, just before sailing from New York, my duties called me to Washington for a day. On leaving, General Grant took me to the station, and expressed his regret that he had thus far not been able to bring about an exploration of the Isthmus. I replied that I did not feel in any degree uneasy as to that, and had no doubt that ere long he would be able to effect it. During the following winter, Senator Conness secured an appropriation for the exploration of the Isthmus, and the subsequent election of General Grant to the Presidency enabled him to have me ordered home, his object being to send me to the Isthmus. Before reaching home, however, other officers had been assigned to two large sur-

veying parties, and I was made chief of a bureau in the Navy Department, and directed to confer with the Secretary of the Navy in relation to the Isthmian surveys then in progress.

In compliance with a resolution of Congress, on the 15th of March, 1872, the President appointed a Commission, consisting of Gen. A. A. Humphreys, Chief of Army Engineers; Capt. C. P. Patterson, Superintendent of Coast Survey, and myself, then Chief of Bureau of Navigation. Our duties were to examine into the entire Isthmian question, make suggestions as to further surveys, etc. The formulation of the orders to the officers engaged in making the surveys was placed in our hands, and we kept the President, who was deeply interested in the results, advised of the progress of the work. After the completion of the Tehuantepec, the Nicaragua and the Atrato-Napipi routes, and the several tentative lines in the vicinity of Caledonia Bay, and lying between it and the water-shed falling into the river Atrato, in South America, the Commission asked for and obtained an inspection of the Nicaragua and Atrato-Napipi routes, which seemed to promise possible practicable canal routes. Major MacFarland and Captain Heuer, of the Engineer Corps of the Army, were assigned to inspect these routes, and Mr. Mitchell, of the Coast Survey, was also ordered. General Ammen was invited, and went in an honorary capacity at the request of General Humphreys, his classmate and friend at the Military Academy, and Mr. Walton, C. E., of Louisiana, also went in an honorary capacity.

In returning, *via* Panama, General Ammen obtained such information as induced him to state to the Commission that although he thought Panama would prove greatly inferior to the Nicaragua route in first cost and still greater in maintenance, he did not see how the Commission could make a report without being subject to proper criticism, unless an instrumental examination of Panama was made and reported upon. As this would delay the completion of our report one year, I heard this opinion with a good deal of disappointment, although quite certain now that this course was a

necessity to free the Commission from possible reproach. At our request, this instrumental examination was made by the same officer in command, accompanied by the same civil engineer and medical officer who were on the Nicaragua survey. It was advantageous in every way that the relative advantages and disadvantages of the two routes should be known and passed upon by the same persons. On the completion of the Panama survey, the great inferiority of that route was shown. The necessity of making it lay in the fact that there was no authentic information obtainable otherwise than by making the survey, to enable the Commission to form an intelligent opinion as to the degree of practicability of that route. A further survey of the Atrato-Napipi route, not asked for by the Commission, established the fallacy of what had been presented as an actual instrumental line of location over a distance of about twenty miles which had not been traversed.

A satisfactory instrumental location, and calculations and plans for a canal across the Isthmus of Panama, was placed before the Commission, and soon after a final report was made, February 7, 1876. (Senate Ex. Doc. No. 15, 46th Congress, 1st Session.) It states: "That the Nicaragua route, beginning on the Atlantic side, at or near Greytown, possesses, both for the construction and maintenance of a canal, greater advantages, and offers fewer difficulties from engineering, commercial and economic points of view, than any one of the other routes shown to be practicable by surveys sufficiently in detail to enable a judgment to be formed of their relative merits, as will be briefly presented in an accompanying memorandum."

The memorandum summarizes the advantages and dis advantages of the various routes examined, from Tehuantepec, with its 754 feet of elevation and difficult, if not deficient water supply, to the Atrato-Napipi route, the farthest south. The routes examined were ten in number, of which three had plans and estimates for ship canals, based on instrumental work, the tentative examinations of the Darien and other routes being ample to show their impracticability.

From the time of the report of the Commission until the expiration of the term of President Grant, there was great political commotion in Congress, and after the Presidential election in November, there was great uncertainty as to the Presidential succession. Nothing was done looking towards the construction of the canal as recommended by the Commission; General Grant was, nevertheless, still earnest in relation to it, and, just previous to his going abroad, called on President Hayes and urged action, and asked me to remind the President of the very great importance of bringing it about under the control and auspices of our Government. The question, nevertheless, slumbered until revived by the Paris Canal Congress, May 15, 1879.

About the time that Lull had completed his surveys on the Isthmus of Panama, in 1875, a discussion was taken up in Paris by the French Section of the International Committee for the exploration of the American Isthmus. M. Drouillet, a French engineer, and the Secretary of the Committee, published a pamphlet in which he gave a synopsis of what he regarded as authorities, and he proposed methods of exploration. Notwithstanding our instrumental surveys and tentative lines over many routes, he came to the United States to make an appeal to our learned societies to lend their aid to make a general and serious exploration of the Isthmus. He asserted that "the problem of inter-oceanic navigation is, at present, incapable of solution on account of the insufficiency of geographical data, and of the flagrant contradictions which exist in these data—an insufficiency and contradictions which do not permit the engineer to study profoundly a definite project."

As a member of the Commission that had made an official report of the sufficiency of authentic information in our possession, I gave a reading before the American Geographical Society, of New York, October 21, 1876, to show that the difficulty was in M. Drouillet not being able to separate what was authentic from what was illusory. Two French expeditions were subsequently sent to the basin of the Gulf of Darien; the first year they elaborated a plan of a sea-level canal from the water-shed of the Gulf of Darien

to the Atlantic coast, with a proposed tunnel of indefinite length, and without visiting the Atlantic terminus. I discussed this route before the American Geographical Society, Nov. 12, 1878. The second year they paid a brief visit to the same region, lost several of their party through sickness, then visited the valley of the Chepo, before mentioned, and took a dozen cross-sections along the line of the Panama Railroad. From these cross-sections plans were produced for the consideration of the sea-level canal at Panama, which, on their presentation to the Paris Congress, elicited the unqualified admiration of M. de Lesseps. The history of the Congress will be found in brief in the reports of Civil Engineer Menocal and myself to the Secretary of State, published in 1879, titled "Instructions to Rear Admiral Ammen," etc. I quote from my report: "That personal interests, arising from a concession for the construction of a canal, are unfavorable to a relative consideration of natural advantages as between two or more routes; that such personal interests did exist was quite apparent from first to last; and the 'concession' was partially discussed or alluded to, especially in the committees or sub-committees."

"That the discussion in Paris has shown that hereafter in the examination of the question, only the Nicaragua and the Panama routes need critical examination, and that sufficient information exists as to all other routes."

"That a canal *a niveau* by the Isthmus of Panama, either with or without a tunnel, has been shown to be hopelessly impracticable, if considered as a commercial question, and a general and special knowledge now exists among European engineers relative to the subject of a ship canal across the American Continent, which did not exist prior to the assemblage of the Congress in Paris."

I recall the well-known fact that the ablest hydraulic engineers of the Society of Paris did not support Lesseps in his sea-level canal project, yet, of course, he had a "majority," but that did not give him a moneyed support. Failing in that, a month later, he announced that he would soon go to Panama "to see for himself," and then be able to inform the French people just what the canal would cost.

Early in December he reached Panama, accompanied by several engineers and contractors. Soon after his return to France, the "American Presidency of the Panama Canal Company," as it was styled, was offered to General Grant, with a salary of 100,000 francs. In declining the offer, the General stated that, however desirous he was of identifying himself with the construction of an inter-oceanic canal, he was not willing to do so with any project that would end in failure. Then the position was given to the "American Minister of Marine," and his acceptance trumpeted as a quasi-endorsement of the canal by our Government. The entire newspaper press of France was "subsidized," that nothing might be published that was not approved by M. de Lesseps. I have recent information that the proprietors of one of the great Parisian journals received 300,000 francs for their aid in deceiving the French people. Then the proverbial French stockings were emptied into his lap. He said a sea-level canal was demanded by the public, and he was sponsor for it.

On reaching home from the Paris Canal Congress I wrote to General Grant, who was then in Japan, urging him to take hold of the construction of the Nicaragua Canal to secure our great national interests, and received a telegram, and later a letter, that he would do so, but unhappily, soon after his arrival in Philadelphia, he was swerved from his purpose. In "Recollections of Grant," published in the *North American Review*, October, 1885, will be found something of interest as to this. Had he remained firm in his purpose there is hardly a doubt that the canal would have been completed years ago. In the same monthly, of February, 1881, will be found a long paper by him on this subject which closes as follows:

"I have formed the opinions expressed in this article not from a hasty consideration of the subject, and not without personal observation. While commanding the Army of the United States, my attention was drawn to the importance of the water communication that I have discussed. During my administration of the Government, I endeavored to impress upon the country the views I then formed, and I

shall feel that I have added one more act of my life to those I have already recorded, if I shall succeed in impressing upon Congress and the people, the high value, as a commercial and industrial enterprise, of this great work, which, if not accomplished by Americans, will undoubtedly be accomplished by some one of our rivals in power and influence."

A month before the meeting of the Paris Canal Congress, M. Blanchet, an emissary of Lesseps, returned from Nicaragua. A very favorable concession for the construction of the Nicaragua Canal was agreed upon between the executive department and himself, which failed in being confirmed by only one vote in the Senate. Soon after M. de Lesseps left Paris for Panama, in the November following the Congress, "to see for himself," information was received that M. Blanchet would soon leave for Nicaragua to make another attempt to secure the concession that had just slipped through his fingers. To forestall this, the late S. L. Phelps, who died while acting as our minister in Peru some years ago, formed a provisional association and sent an agent to Nicaragua, who arrived only two days in advance of Blanchet, and secured as favorable a concession as was desired.

No sooner were the Panama and Nicaragua Canal projects formulated than Captain Eads appeared upon the scene and proposed a ship railway across the Isthmus of Tehuantepec, and an endowment of $60,000,000 to be paid as sections were completed, in guaranteed bonds, counting the navigable parts of rivers as sections, which were nearly navigable without improvement. He had a special committee appointed for the consideration of the canal question, and actually nearly captured a majority to grant him guaranteed bonds to build his ship railway, and under this condition the supposed majority of the committee was willing to report a bill to incorporate the Nicaragua Canal without any guarantee whatever. The attempt to report the Eads bill failed, and thereafter Eads and his following, and the people in Lesseps interest, headed by the "American Syndicate," endowed with an annuity of half a million of dollars,

held watch and ward to prevent the Nicaragua bill being brought up, a very easy thing to do under the rules of the House.

To the ordinary observer of transportation, and to those conversant with navigation, if the question is regarded in a commercial sense, and the danger, if not impossibility of transporting a ship and her cargo across an elevation of 735 feet, with steep and varying grades, a distance of 150 miles, a comparison of economy with her transportation through a canal, having a satisfactory lockage of 110 feet elevation, requiring an excavated prism of less than forty miles in length, as was then known, seems absurd on its face. No ship-builder in the country endorsed his ship railway as practicable, and no insurance company expressed a willingness to take risks, yet Captain Eads had the indorsement of engineers and others who should have known better. I invited the opinions of prominent ship-builders and engineers in our country, and they were, without exception, entirely unfavorable to a ship railway. They stated in general, that a new strong ship would have her cargo taken out, or at least a considerable part of it, before being docked, and that great difficulty would be found in making a solid road-bed, and still greater in having it so level as to distribute the weights equally on the axles, failing in which they would give way. They regarded the idea as impracticable, yet Captain Eads would, in addition, subject the vessel, with a full cargo, to the percussive effect in transit, and give her a journey over hills more than 735 feet high, going at a rate of eight or ten miles an hour, with a road-bed, as his engineer said, "of at least two feet of broken stone." The ship railway required several enormous turn-tables to change direction, that had to be floated by water, and then turned and lowered again on a solid flooring, yet this ship railway was proposed "to save time and money in transit," as compared with a canal having an excavated prism of less than one-third of the length of the proposed ship railway and a lockage of less than one-sixth of its height. The late Col. John G. Stevens, and the late W. W. Evans, both engineers of world-wide reputation, wrote me their ideas that will be

found in pamphlets published by me, copies of which I have presented to the FRANKLIN INSTITUTE. At different times I exposed the impracticability of the Eads ship railway in the daily prints. I received several visits soon after, from a young gentleman who, as he informed me, was an "associate of Eads" and who was desirous that I should join the railway scheme, as it would be much more economical than a canal in the transportation of ships. I said, in reply, that this was just what I objected to, to wit: its entire lack of economy, even were it practicable; that with the experience of an old seaman I did not believe that a laden ship could be taken across on a ship railway and float on being put into the water. Nevertheless, I added, as there might be an honest difference of opinion, and as a fact, I did not wish to oppose Eads so long as his project would not be detrimental to great national interests, I had no objection to, and would not oppose any bill giving Captain Eads, *as a bonus*, just as much as the toll dues received for the transportation of all American ships carrying cargoes, having a gross weight or displacement of 2,000 tons or more, until the Captain received in full, and as a bonus, all that he asked for on guaranteed bonds. This suggestion was rejected with scorn, and confirmed me in the belief that Eads wished the Government to bear the loss of an experiment which would at least yield to him and his associates possession of a four-track railroad, very substantially built on a Government guarantee of bonds, and a line of traffic for grain and other commodities very much better situated, geographically and otherwise, than the Panama Railroad. In all this contention with Captain Eads I was not able to get him to produce a profile, yet the Eads influence embarrassed those interested in the construction of the Nicaragua Canal to the time of his death in March, 1887, covertly aided by the American Syndicate with its annuity of $500,000 "to maintain American Neutrality!" They had the adventitious aid of a pretended friend to the Nicaragua Canal Association, but an insidious foe, not to the construction of the canal, but aiding in the prevention of an act of incorporation through coveting the construction of the canal as a Government work,

and this was no less a personage than the Secretary of State.

After the expiration of the concession in September, 1884, at the invitation of the State Department, General Zavala, a former President of Nicaragua, a gentleman of great ability and character, came to Washington to negotiate a treaty looking to the construction of a canal as a Government work. Whatever influence I and some other former associates had with him was directed towards favoring the Secretary of State.

The apparent feebleness of the Association that held the Nicaragua Canal concession grew out of the fact that it was composed entirely of persons who appreciated the necessity of securing the construction of the canal in a manner not adverse to American interests. They were willing at any time to deliver over their franchises to the Government, had it been possible, or to have the work done themselves, and only asked an act of incorporation from Congress without any guarantee, until they found themselves confronted in prevention by the two great engineers, M. de Lesseps and Captain Eads. A guarantee of three per cent. was then asked, to be operative only when the canal itself was operative or doing its work for a period of twenty years. This meant only an assured protection of the canal by the Government.

However questionable the proceedings of Mr. Frelinghuysen were, and regardless of personal rights, the members of the Association would not have felt that their efforts had been in vain had they ended in the Government securing to itself the actual construction of the canal. But Mr. Frelinghuysen was not able to have the treaty confirmed. It is supposed to have been opposed by the powerful influence of the incoming Administration, and subsequently withdrawn by it, as stated at the time in the public prints, for consideration or modification. The next Congress was informed in the President's Annual Message, in December, that the treaty would not be again presented for confirmation. It was not thought worth while to ask of Nicaragua any amendments. It was supposed by our State Depart-

ment to be only worthy of being trampled under foot, but being trampled under foot by our Government would only give an undoubted advantage to the citizens of any other government to obtain a concession, and aided in any effective way by their government occupy this vantage ground to our detriment, as General Grant suggested would occur, should it be neglected by us, and this certainly would have occurred had it not been for the subsequent prompt action of citizens of the United States.

Much that I have said would have little relevancy to Isthmian transit, were it not that it shows beyond question that the impediments in the way of the construction of the Nicaragua Canal have not been of a physical nature, but vile machinations, which yet continue. In March, 1887, when Eads was expending his dying efforts in opposing the passage of an act of incorporation for the Nicaragua Canal Company, and M. Colné, the Secretary of the American Syndicate, "to maintain the neutrality of our Government" through its annuity of $500,000, was in Washington, doubtless to aid in preventing the passage of the bill, Colné gave out a telegram, received from Paris, that "M. de Lesseps would be gratified to see the Nicaragua Canal constructed; the water being fresh, would serve for irrigation, but no vessel would pass through it; they would prefer a Cape Horn voyage." It was well known to us, that for months before, the only "plan" then entertained for the construction of the Panama Canal was for a lockage of about 150 feet elevation, and for a draught of water of only about fifteen feet. Had the Panama Canal opposition ceased with this, I would have had little if anything to say of it, but it continues in one form or another, aided by influences from other quarters, the effects of which at least are apparent. A telegram from London, published in the Washington *Star*, of July 9th, states:

"Arms and money have been poured into Costa Rica, and she is in a far better condition for war than Nicaragua. It can be guessed where such opportune aid came from, and while it cannot be expected that the parties interested will openly acknowledge their implication, there is open rejoic-

ing in Paris at the promise of serious complications. A former power on the Bourse, who has been almost as completely wrecked by the collapse of the Panama Canal shares, as M. Secretan was by the copper speculation, says: 'From the inception of the Panama Canal scheme the United States has proved its most bitter and relentless enemy. By its irritating and threatening references to the ill-defined and impudent Monroe doctrine, it prevented the investment of English capital in the enterprise, and deprived it of the benefit of that English conservatism that would have so admirably supplemented French genius and secured a brilliant success for the greatest triumph of man over nature. It cannot be expected that we will sit with folded hands and see the results of our labor and expenditure rendered nugatory, as it would be by the completion of a canal through Nicaragua. We do not believe that the United States will make war upon Costa Rica for the benefit of a private company, which State would be placed in position of defending rights which, as a State, she had never surrendered.'"

I have no faith in this idea that men can "triumph over nature." It was this vain attempt, not the United States, as a bitter relentless enemy, that destroyed the Panama Canal. All that men can do, in my belief, is to study closely and execute in their interest what nature favors or permits, as we shall see Humboldt said long ago in relation to Nicaragua. Our countrymen would not believe that the United States were "making war for the benefit of a company," were it declared in the most emphatic manner, by force, if necessary, that the concessionary rights granted by both republics referred to, would be sustained and protected in the most ample manner, and, on the other hand, see to it that the canal company should fulfil all of the obligations entered into, and imposed upon it by the terms of the concessions. Any other course would leave the company open to perpetual embarrassments by European speculators, in the hope eventually of bankrupting it and getting the benefit not only of the marked physical conditions shown to exist, the results of thorough surveys, but also of all the labor and material expended up to the time of failure. The interests

of a canal company, however large, will be a mere fractional part of the great collateral interests that will grow up, even in anticipation of the completion of the canal.

A telegram from Panama, dated October 15th, announces that the *Suez Canal Company* has arranged with the government of Guatemala for the purchase of a railroad to be completed from the Atlantic to the Pacific, and to put into that country $21,312,000 in gold. As railroad men express it, this is "to parallel the Nicaragua Canal." With what has just been said, in relation to Costa Rica, my hearers will not be slow to perceive in this movement the fine hand of M. de Lesseps, the President of the Suez Canal Company. It is not unlikely that our Government may find itself compelled to repress hostilities on either side of Nicaragua, incited by the Eastern diplomacy of M. de Lesseps. The railroad in itself, passing over an exceedingly rough country at an elevation of not less than 5,000 feet, and a length not less than 300 miles, would hardly "handicap" such a work as the Nicaragua Canal; but it is plainly an indication that Suez Canal influence and money will be used to "bull" and to "bear" Nicaragua Canal stock, should it be issued upon such a financial basis as would permit it.

In looking at the construction of a canal across the Isthmus, the health question will be found the most important, even in a commercial point of view, and the humanitarian will be pleased to know that there is perhaps no country on the globe where the canal could be made, with less loss of life from disease than on the route of the Nicaragua Canal as now located. It lies between latitude 12° and 10½° north, directly in the trade wind belt and has an extreme range of temperature throughout the year of but 17°, which we all know is less than a usual daily change with us, for a large number of days in every month in the year. The general direction from Greytown to Brito is a little north of west, and the natural summit above full lake is only forty-three feet. Owing in part to the high mountains that lie at some distance on either side of the river San Juan, which is the out-

flow of the lake, a funnel-shaped entrance is given to the trade winds which traverse this district with great climatic advantage. There is a popular idea, and unhappily generally founded in fact, that human life in the tropics is ephemeral in a greater degree than in the temperate zone; that disease and death come from pestilential air; that beasts of prey pounce upon and devour the wayfarer; that deadly serpents lie in the tall weeds and thorny shrubs, that cover the ground beneath enormous trees, thickly canopied with vines and leaves, so thick that the rays of even the noon-day sun give only an obscure light.

The pestilential climate of Panama is indisputable; Puerto Bello, in the Gulf of San Blas, not far from Aspinwall, was abandoned from its extreme unhealthfulness, and the attempt of Paterson to colonize at Caledonia Bay was a failure quite as much from disease as from the fact that no practicable waterway was to be found across the Isthmus at that point, and no portage as favorable as at Panama.

That the healthfulness of Nicaragua, however, is exceptional for a tropical region, as I shall show presently, is well established as a fact.

In British India and on the Island of Singapore, statistics show an enormous loss of life through the ravages of wild beasts, and the bites of deadly serpents, amounting to tens of thousands of victims yearly. Although the jaguar and cougar abound on this continent from the boundary of Texas to Patagonia, they do not attack men, and although there are venomous serpents in all inter-tropical America, they are not numerous, and are an imaginary rather than a real danger, shown from the fact that in the many surveys made by our Government, not one man has been fatally bitten, if bitten at all. The wild beasts although numerous were never seen, even in their haunts in the thick forests traversed by the surveyors. The Chief Signal officer of our Government adds another tribute to the climate of this region, from his observations: "Exempt from hurricanes and whirlwinds, owing to the constant movement of air across the Isthmus from the trade winds, although light in the rainy season." When this canal is made, as it doubt-

less soon will be, the region lying between the lakes and the Pacific will be the great sanitarium of Europe and the United States, as it will then be easy of access and will be found to fulfil the required conditions more fully than any other region known.

Seven years ago, I made the acquaintance of an English gentleman, who asked if I had read a book published in London some years before, entitled "A Naturalist in Nicaragua." I subsequently read the book with great interest and instruction. It treats of the healthfulness of the climate, even at Greytown, and the causes of it. On mentioning this to Medical Director Maccoun, of the Navy, he informed me that his personal observation at Greytown, in relation to the type of fever at that port, confirmed the statements of the writer referred to.

It was quite amenable to treatment and quite different from the "pernicious" and other deadly fevers that afflict the Isthmus of Panama. In the sitting of the Association for the Advancement of Science in the city of New York in August, 1887, Surgeon Bransford, of the Navy, gave his ideas in relation to the causes of this exceptional healthfulness of Nicaragua as compared to most inter-tropical countries. He had been the medical officer of the several expeditions sent to Nicaragua, and was competent to express an opinion in relation to the subject. He had also been on the Panama survey, and therefore able to appreciate the wide difference between the two localities. In December, 1887, sixty surveyors and assistants landed at Greytown, accompanied by 100 or more Jamaicans, and had a further accession of force of forty natives. The rainy season prevailed a month or more beyond the usual period, and during that time they were exposed in their tents and in the forests, engaged in work of an arduous nature, and this exposure continued for a period of six months without a case of serious illness in the entire party. What was remarkable, the Jamaicans were far more liable to ailment than our countrymen. This climatic difference, so well established as not to admit of dispute, if looked at only in a commercial point of view, is of immense advantage in relation to the execution of a

canal, in economy of time and money in Nicaragua, and the reverse on the Isthmus of Panama.

Sir John Hawkshaw said at the Paris Congress, in discussing the Panama Canal: "With regard to the question whether the canal should be constructed with or without locks, the following points occur to me—if the canal is to be without locks, its normal service level would be that of the sea, and its bottom level say eight metres lower. This being the case, the canal would receive and must provide for the whole drainage transversed. Therefore, it would be necessary to ascertain the volume of water that would drain into the canal before it would be possible even to determine the sectional area of the canal. If the canal have a less surface fall than the river, as it would have, it must have a larger sectional area to discharge the same volume of water. If, from such considerations as the foregoing, it should be concluded that the canal should be constructed so as to retain the rivers for natural drainage, then recourse will have to be had to locks. In that event there can be no difficulty, in my opinion, in carrying on the traffic with locks properly constructed, provided there is an ample water supply, which would be a *sine qua non*."

Sir John was regarded as able a hydraulic engineer as was known in Great Britain, and attended the Paris Canal Congress at the instance of his government. Although what he said were axioms with hydraulic engineers the world over, and his points were stated with great clearness, yet his words had no meaning for M. de Lesseps, and no endeavor to control the surface drainage of the Panama Canal has thus far been attempted. Abandoning "temporarily," M. de Lesseps said nearly three years ago, the immediate construction of a sea-level canal, his "plans" then disregarded furnishing the lock canal with a permanent water supply at the summit, and proposed pumping up thirty-three feet the deficiency. We know that in very dry seasons the Chagres River itself will furnish an inadequate water supply at 124 feet above sea, the height proposed by Lull in his plan.

In a report of Lieut. C. C. Rogers, of the Navy, recently published, there is information given out in great part from

the canal company at Panama, in March, 1887. The statements are very like reading a hopeful account of a sick patient a year or so after he has died. On page 31 is found: "It is now time to consider the dam of the Chagres at Gamboa. * * * The central line of the dam will cross the Chagres at a distance of 500 metres from the axis of the canal at the forty-fifth kilometre. The length of the dam at the base will be 300 metres; the level of its crest will be plus thirty-five metres, and the whole dam will contain 10,000,000 cubic metres of material. The geology of the Gamboa district has been studied during the past year, and it has been found that the weight of the dam when complete will be sustained by the ground beneath without need of piling or other artificial support." The Director-General assured him there will be no difficulty or expense involved outside of the dam for the successful formation of a lake whose volume would permit an accumulation of 1,000,000,000 cubic metres of water during the worst rainy season. It would seem superfluous to suggest what would happen to the canal should the basin not prove sufficient to hold all of the water "of the worst rainy season," or should that dam built "sustained by the ground beneath without need of piling or other artificial support" be swept away. A cataclysm would sweep to both seas and destroy every vessel in transit and every living being along the line of canal. But my hearers may be assured that dam will never be built. * * * On page 34 we find: "From all I could learn by conversation with the officials it does not seem that a sea level for the entire canal is a fact of the future. M. Jacquier, the Director-General, told me that a lock might be placed in the Culebra cut; and M. Charles de Lesseps remarked to me once that the canal could be finished two years sooner by building a lock at this point. The Director-General subsequently stated that if a lock were decided upon here it would be only with the agreement that at some stated time in the future the company should be allowed to remove it and excavate the cut to the depth of nine metres below the water line, thus making the canal a sea-level route for its whole length. In the present uncertainty and even doubt

as to the construction of a lock, no plans for it have been made."

Notwithstanding the difficulties that have thus far beset M. de Lesseps and his canal, his ingenuity or that of his able engineers has not been exhausted; although the dam will not be built, nor will water be pumped up thirty-three feet to the summit, it is intended that ships "shall get there all the same." I learn through a friend that M. Colné, the Secretary of the American Canal Syndicate, has just arrived from Paris, where he is supposed to have gone to confer with M. de Lesseps. He states that the canal may be constructed at the sea level, save in the deep cut of which the Culebra forms a part; there they may have a ship railway some five miles in length, or perhaps reaching to Panama Bay. *Chacun à son goût* is a French proverb, and there is no reason why M. de Lesseps should not indulge his taste.

M. de Lesseps knows now, that the "'prentice hand" of engineers may excavate at a grade of 45°; they do not "establish" it; nature then insists in putting on the finishing touches, month after month, until she is satisfied with the grade. The huge masses on the deep cut have slowly approached each other, through the effects of hydrostatic pressure and gravitation, and this would be the more pronounced the deeper the cuts were made. Fifteen years ago, the Superintendent of the Panama Railroad answered an inquiry why he had such steep grades at the summit when so little cutting would be required to lessen them, by stating, that the cut had not been deepened on account of the extreme tendency of the land to slide, and added that on one occasion a slide nipped a train on the summit and it required days to dig it out, and this had to be done by hauling up the mud in buckets. Freeing a ship stuck in the mud by a landslide would be quite a serious affair, and for years.

In the *North American Review*, of January, 1880, M. de Lesseps gave his views on the Panama Canal, in which he states: "I do not hesitate to declare that the Panama Canal will be easier to begin, to finish, and to maintain, than the

Canal of Suez." Nearly ten years later, the correspondent of the New York *Times*, September 9th, gives his observations: "For twenty-five cents of Colombian silver one may hire a small one-horse victoria, with a negro driver, to take you to the mouth of the canal at Panama. The drive is about two miles, on a road well shaded with all varieties of tropical trees, and is well worth taking, even if you do see nothing but a dirty ditch at the other end. The work at this 'show point,' so to speak, was so slovenly done that it is difficult to distinguish the lines of the canal at high water, and at low tide it has no more water than a New Jersey mud flat. Further inland, passing a few dredgers, the bed of the cut becomes a pasture for the cattle in the vicinity, and a few steps further along bring you to banana trees growing in the 'track of the future commerce of the world.' On the entire line there are now employed 100 men. They are watchmen and others who carry paint pots to paint the hundreds of rusting engines. Near the Culebra cut there must be fifty-odd fine engines, which, with their fresh coats of paint, present quite a prosperous appearance, in strong contrast to that of two years ago, when everything was going to rack and ruin through criminal neglect. The engines and the iron work I formerly saw half buried in the mud at the foot of the mountain, are now out of sight, probably to be unearthed by future generations of canal-builders, and to be regarded as evidence of the ingenuity of their ancestors as far back as the nineteenth century. How the French storekeeper accounts, even on paper, for his material, is a mystery even to an army quartermaster. Engines here on their backs and engines there on their sides may all be accounted for, even if the chaos of the Culebra cut does not remind one of the Johnstown disaster, but for the buried iron work and machines he has only one recourse—to dig down to them now, while they are not deep under ground, attach a chain to them, having on the upper or surface end an automatic-sounding buoy, to determine their position in the next overflow of the Chagres, and to continue the same plan with those that will be buried annually, as the years roll by."

We may turn with satisfaction from the wretchedly conceived and mismanaged affairs at Panama, to the ideas of the great Humboldt, who visited this continent ninety years ago. Seventy-five years ago, he wrote upon "the practicability of a water communication between the Atlantic and Pacific Oceans," to be found in his personal narrative, published in London, in 1826. I quote his words: "It would be imprudent, I here repeat, to begin at one point without having examined and levelled others; and it would be above all to be regretted if the work were undertaken on too small a scale; for in works of this description the expense does not augment in proportion to the section of the canals, or the breadth of the water channel. * * * The Isthmus of Nicaragua, by the position of its inland lake, and the communication of that lake with the Atlantic by the Rio San Juan, presents several features of resemblance with that neck of land in the Scotch Highlands, where the River Ness forms a natural communication between the mountain lakes and the Gulf of Murray. At Nicaragua, as in the Scotch Highlands, there would be but one narrow ridge to pass over; for if the River San Juan in a great part of its course is from twenty to forty feet deep, as is asserted, it would only require to be rendered navigable by means of weirs or lateral canals. * * * It appears somewhat probable that the province of Nicaragua will be fixed upon for the great work of the junction of the two oceans; and in that case it will not be necessary to form a line constantly navigable. The Isthmus to be passed over is only from four to five marine leagues; there are some hills in the narrowest part between the western bank of the Lake of Nicaragua and the Gulf of Papagayo." At the time Humboldt wrote what has been quoted, no instruments of precision, as far as known, had been used on any part of the several routes named by him as worthy of examination. It seems wonderful that the prescience of this great man should have enabled him to name not only the locality favored by nature for the construction of a ship canal, but as well the actual plan of development, analogous to the Caledonia Canal, of which he makes mention and looked upon with admiration.

The Paris Canal Congress had before it all of the information relating to the Panama route made known to us through our surveys, to which apparently little has been added of practical value by the French, and it had also all that we then knew in relation to the Nicaragua route, which was then insufficient to warrant a development analagous to the Caledonia Canal, which further examinations permitted to a greater degree of advantage than the Caledonia Canal itself. Any of my hearers can assure themselves at their leisure of this fact by a patient examination of the *Engineering News* of September 14th. The profile and plans are given in detail, and do not require an engineer to understand them; they are clearly comprehensible to any one who will take the pains to examine them carefully and read the text relating to them.

The length of transit from sea to sea is 170 miles in a north by west direction from Greytown, the Atlantic entrance; there are three locks on each side, and the elevation of the lake above sea 110 feet, as maintained by a dam sixty-four miles down the San Juan River, the outflow of the surplus waters of the lake. By means of this dam and embankments, the lake level is extended over a distance of 152 miles, of which there is free navigation in the lake, river, and basins of 143 miles, and in excavation, nine miles; the excavations at the sea level are designed to have a surface width of 320 feet and thirty in depth, making a fair rate of speed practicable for vessels, and to pass each other in transit. On the Atlantic side, where the sea-level canal to the first lock will be eleven miles, there is a diurnal tide of only twenty inches. Were it twenty feet, as at Panama, it would require a tide-lock to prevent scour and deposits. The country is entirely flat, and the heavy embankments of the material excavated, flumed to 200 yards or more from the line of canal, will make the surface drainage actually only that which falls on the area. This is a marked contrast with the great surface drainage that would damage every mile of the Panama Canal were it built. Long weirs on the basin of the San Francisco River, and on the right bank of the River San Carlos as proposed, will effectually protect the

rivers and basins from the effects of surface drainage. The two axioms of hydraulic engineers, abundant water supply and good surface drainage, are perhaps better met on this line of transit than on any canal of the same length on the globe.

The time supposed necessary to effect a lockage is very greatly exaggerated in the public mind. At the Paris Canal Congress, Sir John Hawkshaw put it at fifteen minutes. At St. Mary's Falls, where our Government has the largest lift lock known, with a lift of eighteen feet, a lockage can be effected in thirteen minutes. In the construction of the canal there is a deep rock cut nearly three miles long near Greytown; a good part of the material will be required to construct a considerable mole at the entrance at Greytown, and a dam at Ochoa; there is other heavy work in blasting and in deepening a part of the river and lake. Humboldt half feared that the cut between the lake and the Pacific might be considerable, when it is found only forty-three feet above full lake, and quite five miles of the navigable distance is made by means of an embankment. Looking at the deep rock cut on the eastern side, near Greytown, it is worth while to bear in mind that making it is purely voluntary, and far preferable, as a choice, to excavating less than twenty miles of additional prism, which would flank all deep cuts. I am not disposed to belittle the quantity of work that will be required to construct the canal, even in this locality, so favored by nature; especially in the fact that when a given part of the work is done, it will not be destroyed or even seriously increased by landslides and washes. Adding much to the economy, and quite unlike Panama, it has convenient dumping grounds along the whole line, and every part of the work can be attacked without interference as soon as the plant is in place, which will require time.

In the Paris Congress, I said that in the consideration of a ship canal across this continent, we may well suppose that its permanency should be regarded as important as the selection of the route itself, involving the least cost of construction with the minimum of problems of doubtful cost

in the execution of the work. With these points assured, the question becomes fairly debatable whether the physical conditions are to be considered too formidable to admit of the execution of the work as a commercial or monetary question—in fact, whether a grand idea for the amelioration of the great commerce of the world can be put in execution, or perforce abandoned, through the existence of obstacles too formidable in their nature to overcome them.

With the facts before him, as presented in the *Engineering News*, of September 14th, an engineer can form an approximate estimate of the cost of the canal. If money can be obtained without discount, it would cost one sum, if not, quite another sum. If the Government should take a first mortgage by guaranteeing three per cent. interest on $100,000,000 bonds for a term of years, the cost would be reduced to a minimum, so far as the money question is concerned. If the company has to look about and obtain funds at home and abroad, without other guarantee than the successful completion of the work, the cost of the execution of the canal would perhaps be widely different. In this case, the traffic of the world passing through the canal, and not the company, would eventually pay the difference in that much additional charge on toll rates. If owing to this and other considerations, the canal should cost $250,000,000, in my belief it would not be the less munificent in its reward to stockholders. With its moneyed support assured on a basis of three per cent. bonds at par as issued, the canal including interest on bonds, should not cost more than $150,000,000, if indeed that much. Should the company fail, the Government would be secured as a private and not as a Government owner. It could then complete the work with entire profit to itself, and control it as an owner, subject of course to all of the obligations and restrictions that the company entered into with the respective governments of Nicaragua and Costa Rica, and having no other rights or powers than belonged to the company through its concessions. As the collateral benefits that would be derived from the construction of the canal to the country would be many times greater than the benefits the

company would derive through its investment, it would seem an obligation on the part of the Government to enable the company to raise its money on the sale of stock and bonds without discount, the more as it would have ample security; a guarantee would only amount to a substantial expression as to the commercial practicability of the canal when completed, and as stated before, the toll rates being limited, after ten years, and dependent on the cost, would actually be that much of an economy, and just in proportion as it would free the company from a larger rate of interest and from the operations of "bulls and bears." I have already shown the intrigues of the Panama Canal Company, in Costa Rica, and M. de Lesseps, President of the Suez Canal Company, shows his hand now in Guatemala. These are questions that properly belong to statesmen and to financiers, with the fact demonstrable, that should the canal cost when completed $250,000,000, it would nevertheless be a sound, and soon after completion, a munificent investment. This of course must depend upon its traffic and the toll dues resulting. Look at a map, or better still, with a globe before you, cast a glance along the coast lines north and south from Brito, the intended Pacific port of the canal. Peopled as it is now, from north to south, this coast would in itself yield an enormous revenue. Look then toward Japan, the northern coast of China, the Philippine Islands, and in the southern hemisphere, the eastern coast of Australia and New Zealand. All of the traffic from these regions, not only with us but to Europe, would pass through the canal, save sailing vessels bound to Europe from Australia and New Zealand, that would pass around Cape Horn, and returning, through the canal.

There is one traffic alone, now of small dimensions, that will increase enormously as soon as the canal is available—the timber trade of the northwest coast to Europe and our eastern coast. We all know that the supply of the Atlantic water-shed is well-nigh exhausted, from use and destructive forest fires, and this includes Michigan and all that region. Governor Alger told a friend one year ago that it would not hold out longer than five years. In the Southern States

there is yet a considerable amount of yellow pine, but almost all of it is distant from lines of cheap transportation. On the Pacific slope, and even near the coast, there has been wanton destruction of timber, and recently forest fires have swept the country for hundreds of miles, so that the shores of Columbia River and of Puget Sound even, cannot longer be relied upon beyond furnishing local supplies and markets near at hand. Distant as the voyage was around Cape Horn, dozens of ships have made it yearly, laden with timber from Puget Sound to Europe and our eastern coast. Happily there remains an enormous region yet intact, extending northwest from Puget Sound, perhaps 600 miles, and having a mean breadth of 100 miles or more, an immense archipelago, with convenient channel ways, lying between long narrow islands, affording great facilities for transporting the logs to mills and loading lumber into ships when sawed. Nowhere on the globe are more economic means of cutting and loading than in Columbia River and Puget Sound, nor is there timber in quality found elsewhere in quantities as the yellow cedar and the firs of Princess Charlotte and the neighboring islands of the archipelago referred to. A canoe dug out of a yellow cedar log, eight feet in diameter and fifty-nine feet long, is to be seen in the National Museum in Washington. The mass of timber to the acre would astound even a Maine lumberman. The climate is damp and forest fires would be almost impossible; should they occur they would at most be limited to an island, and what adds greatly to the security of the timber, is the fact that the cupidity of man is appealed to in utilizing it to his profit rather than in destroying it to cultivate the land. This timber supply will last for centuries, but cannot be availed of except at great cost of transportation until the canal is made. On its completion hundreds of vessels will be engaged in carrying it to profitable markets, and the grain product, now quite considerable, and carried to Europe although handicapped by a Cape Horn voyage. These two products would form a very considerable part of the traffic for the canal were it now operative.

The *Engineering News* referred to, makes an admirable

comparison of the two canal routes, as follows: "At Nicaragua there is no unsolvable Chagres River problem; there is much less canal in excavation; there is much less deep cutting; there is no problem of water supply; there is no rotten sliding rock; there are no endemic pestilences; there is a stiff trade breeze blowing all the year round to maintain health and comfort; there is a prior knowledge from detail surveys of just what is to be done, which was wholly lacking at Panama; there is the advantage of all the experience gained at Panama; and of an official 'base' on this side of the ocean, instead of on the other side; and there is the practical certainty of far better management. These are enormous advantages, and it therefore seems to us that no reasonable man can doubt, first, that the canal can be built for $100,000,000 to $150,000,000 at the very most, and secondly, that it will be exceedingly profitable even at that rate."

That the Nicaragua Canal will be constructed, and without delay, is assured by these facts, which tell not the less why the Panama Canal was a failure and will never be completed. In the Paris Canal Congress, authorized by the Executive Department of our Government, I said that the people of the United States are not disposed to consider the construction of an Isthmian canal, solely with reference to the degree in which the commerce and interests of the United States will be relatively benefited through its construction as compared with the advantages that may accrue to other commercial nations. Such a ship canal cannot fail to be a great and common benefit, and especially in opening a rapid and easy transit between the Atlantic coasts of Europe and America with the western coast of America, and the speedy development of Australia. Regarding this inter-oceanic ship canal, when constructed, as the greatest artificial highway that can be constructed, conferring benefits on all nations and peoples, the people of the United States consider its construction as one of common interest, and the guarantee of its neutrality a duty in common to all nations.

MUNICIPAL ENGINEERING—A STUDY OF STREET PAVEMENTS.

By Lewis M. Haupt.

[*A lecture delivered before the* Franklin Institute, *November 8, 1889.*]

Professor Haupt was introduced by Prof. Coleman Sellers, and spoke as follows:

Ladies and Gentlemen:

Under peculiarly delicate and suggestive circumstances, the poet Burns produced the familiar epigram:

"Oh! wad some power the giftie gie us,
To see oursels as others see us!
It wad frae monie a blunder free us,
And foolish notion."

Although the circumstances and conditions are entirely different, nevertheless we may profitably invoke the same spirit to aid us in the investigations we are about to enter upon.

There are times in the life of every community, as in that of an individual, when such introspection becomes a necessity to the municipal as well as the moral development. We must first become conscious of our defects before we can hope to correct them, and therefore a few words are necessary as to the existence and character of these defects.

In general, external appearances are the criteria of the internal directing forces, hence when one sees an individual clad in rags, the conclusion is reached that he must be either a pauper, a miser, a prodigal or a debtor, and that he is lacking in the energy and thrift which would lift him to a higher level.

Like causes will produce like effects, whether taken collectively or singly, and hence we will find that a community in which improper or inadequate provision is made for the

physical wants of its members, must be the victim of penury, debt, mismanagement or incompetency.

The visible evidence of such a condition, if it exists, are to be found in the public works of a great city, and the gauge can be most readily applied by comparisons.

But, since comparisons are sometimes odious, it should be understood from the first that these are presented, not for the purpose of reflecting upon the character of our public improvements, but that, as interested citizens and taxpayers, we may realize so fully and impressively our actual condition as to lead to prompt, definite and concerted action for their amelioration, should it be deemed to be necessary.

The question then before us may be thus formulated: Are we getting the best results obtainable for the money expended, or is there room for improvement in the character of our public works?

If we look to the press, as indicative of the public sentiment, for a reply, we will find a widespread and outspoken dissatisfaction. While we have not space to multiply instances, a few examples will suffice. At a recent dedication of one of our public schools, one of the speakers, an eminent judge of the Orphans' Court, in referring to false municipal economy, said:

"There are two kinds of economy; one which cheapens the first cost of a commodity or an enterprise and reckons its losses afterwards, and another which counts nothing cheap at the outset which will not produce a profit in the end. In Philadelphia we have stuck with Puritan obstinacy to the economy of cheapness. We have cheap taxes and large debts. We have cheap pavements, which break up when we use them, and cheap sewers, which break up themselves. We have cheap court-houses, whose odors are more fatal to the jury than to the criminals, and cheap school-houses, which give steady employment to sextons and undertakers. There are times when we are without gas, but there is no season when we are without a gas bill; when we are short of water the city supplies us with mud, and charges us the same price for both fluids. It is about time to draw the line somewhere in this economy of cheapness."—*Public Ledger.*

Dr. Theodore L. Cuyler, in one of his letters from England, in the New York *Evangelist*, says:

We excel our British kinsfolk in the comforts of railway travel quite as

much as they excel us in the character of their country roads and city pavements. In fact, our city streets are mainly a relic of barbarism, in their roughness and indescribable filth. With the exception of Washington, there is hardly a city in America whose public thoroughfares are not for the most part a public disgrace. I dread the thought of exchanging this clean, smooth sea for the jolts and thumps of New York's and Brooklyn's unclean and unmerciful pavements. But for our fine elevated railways, locomotion would be a torment.

A recent number of an able, independent and influential periodical* contains these remarks:

Seeing that there is deep-rooted, although incomprehensible, prejudice in this city in favor of existing forms of sewers, in favor of the present sources of water supply and in favor of stone block pavements, it would be a good idea to have appointed a commission of scientific men, eminent in position and expert enough to command public confidence, to examine and report upon all these matters. There is, in fact, an absence of exact, full, authoritative information upon the involved subjects, every one of which touches closely the health, the comfort and the wealth of the whole body of citizens. We are about to appropriate large sums of money for water, sewers and pavements, and we affirm that most of the money is to be completely thrown away, because it is to be expended in an effort to improve a hopelessly botched job. We doubt if there is a quarter of a mile of sewer under Philadelphia that is constructed as a sewer ought to be; that is, as a water-tight conduit. We also doubt if there is a quart of wholesome water in the city outside of a drug store. We are positively certain that there is not a square yard of stone pavement that meets the requirements of modern civilization. It is worse than absurd for us to go scrambling along upon the old lines, throwing money away upon improvements that do not improve, etc.

This same paper, in another issue, emphatically says, in reference to the size of the city:

Mere bigness does not involve excellence, although men appear to regard it as the solitary thing of value. We have the greatest city hall on the continent, and on its high tower is to stand the largest statue in this part of the world; but what is there to boast of in that fact, if the people of Kensington have typhoid-tainted water pumped to them? We have the most extensive park belonging to any American city, but why should we contemplate it with satisfaction when every avenue leading to it is covered with a pavement that is disgraceful to a civilized community?

It adds, moreover, a deduction from these and other criticisms to the effect that—

Philadelphia will be truly great, be her dimensions little or big, when life

* *The Manufacturer.*

within her borders may be comfortable, cleanly, healthful and peaceful, and when her public affairs are controlled and administered by her wisest and best men, without any assistance from her criminal classes. * * * If she is to hold her place among American cities she will have to deserve to hold it by completely reforming the scandalous condition of her streets, her sewers, her water supply and the corruption that taints her politics.

Are these criticisms just? Does our city of homes merit the stigma that has been put upon her of being the worst-paved, worst-drained and worst-managed city of its size in the world?

These questions can be answered in part by comparing her public works with those of other cities of equal importance, yet there are persons who think it a sufficient answer to say that the death rate in Philadelphia is as low or lower than in most other places, and hence conclude that it is salubrious enough and there is no need of reform. But this is a mere evasion, for it is manifest to all that there are many removable causes of injury and disease existing, the absence of which might elevate this city to the enviable position of being the healthiest in the world. The present low death rate* may be attributed more to the absence of tenement houses than to general cleanliness of the streets and sewers or the purity of the water, yet the very extent of the city resulting from this spreading out of the population imposes another heavy burden upon the citizen in the shape of long distances to be traversed, for which no sufficiently rapid conveyances are available.

It is manifestly impossible for us to review so broad a field as that included in the public works of a city in the time devoted to this lecture, but as an instance of the character of these works, most of which, as well as their

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* The death rate per thousand is for Rome, 28; for New York, 26·9; for Manchester, England, 26·4; for Vienna, 25; Boston, 23·23; Glasgow, 22·80; Brooklyn, 22·72; Paris, 22·50; Philadelphia, 20·72; Liverpool, 20·20, and for London, 18·70, but in consequence of the cleanliness of the streets and the improvements made in the tenement flats, the death rate of London has been lowered to 15·90 in 1888.

In 1887, the death rate in the improved tenements of London was only 12·5, or less than one-half of that in American cities.—*Phila. Ledger*, October 24th. Extract from a paper by Civil Engineer White, of Brooklyn.

cost, have come to us by inheritance, let us examine the *streets*, which are visible to every one having occasion to use them, whether denizen or alien.

Streets are fundamentally thoroughfares, designed to furnish means of communication from any part of a city to any other part, hence they should lead in every possible direction, and a plan which, as in the old city proper, provides for rectilinear movement in only four directions, is defective and imposes a restraint or a burden upon those citizens who are compelled to live on the diagonals. Again, the space taken for streets is deducted from the total area and is sustained by a general tax upon the remaining territory. It should, therefore, not be larger than is necessary for the purpose. This limit will be found to be at about thirty per cent. Moreover, the width of the various streets and avenues should bear some relation to the character of the traffic and dimensions of the vehicles intended to pass over them. It is no infrequent occurrence to find a blockade, caused by a coal cart or a moving van, backed against a curb. In many cases, also, there is a waste of space because there is not sufficient width between curb and tram-rail for any vehicle, either to stand or move. These defects become very apparent after the street is built upon and the traffic becomes large, and when it is too late to correct them, excepting at great expense. But there is another class of defects more manifest and more easily remedied, which relate to the

PAVEMENTS.

Although volumes have been written on this subject and mankind has been constructing pavements almost since the foundation of the world, the lessons of experience do not appear to have left a serious impression. We only know that our streets are intended to be paved with the best materials available, laid under carefully-worded specifications, and yet, in a few days or weeks, we find them developing weak spots, and yielding to pressure or rains, which make repairs necessary. Why is this and where is the defect? There can be but one answer and that is, because

a structure will not stand unless supported, and *a compressible soil is not a sufficient foundation for a street pavement.* Provide an unyielding substructure and the superstructure will last almost indefinitely. The fundamental requirements of a durable pavement are, a substantial foundation and a suitable wearing surface. *The vital defect of our city pavements is in the character of this foundation.*

Thus Section No. 7 of the Specifications for Block Pavements, whether of "granite," Pennsylvania, Lambertville or asphalt blocks, requires that "the foundation gravel shall be sharp, clean, free from top-soil, rubbish or perishable material, and contain by weight not more than fifteen per cent. of clay, loam, dust or material that will make mud, or be displaced by slowly-running water."

Hence, it appears that the foundation should be composed of carefully selected material, designed to furnish a porous cushion for the escape of surface or subsoil water. Since screened ashes possesses this property in an eminent degree, it has come to be regarded as a suitable substitute for the foundation gravel as required by the specifications. At least we must so conclude from the large quantity of ashes to be found underlying our pavements. The mere drainage of the subsoil is, however, but a minor function of the foundation. *Its main purpose is to carry the load and distribute it from the points of contact over as large a surface as possible. It needs no second thought to realize that an arch, or layer, of foundation gravel or of ashes, possessing little or no coherence, is about as poor a structure to perform this service as can well be devised,* and that the main reliance must be placed on the surface covering, both for strength and wear. If this covering is composed of small units, it possesses inherent elements of weakness at every joint, and the ability of the pavement to do its work will depend more upon the strength of the joints than upon anything else. Hence, the smaller the number of joints the better for strength.

But leaving the subject of the wearing surface for further consideration, let us look again at the foundation. We have just seen that it is inherently weak because of its material, let us now consider its dimensions.

Section 3, of the Specification, says:

Excavation and grading. "The street shall be excavated and graded from curb to curb accurately to sub-grade, fifteen inches below the finished grade;

Laying of foundation course. then, covered with sharp foundation gravel, to be applied in sufficient quantity and thoroughly compacted by rolling or ramming until the new surface, from curb to curb, is exactly nine inches below finished grade;

The bedding course. sharp washed paving sand or gravel shall then be spread upon the compacted foundation gravel to the requisite depth,

Manner of setting the blocks. and the stone paving blocks at once put in place, being set vertically on edge, in close contact with each other, and in straight rows square across the street, except at intersections,

Intersections. which shall be paved at an angle of 45° to the lines of the intersecting roadways.

Precaution. Care shall be taken that blocks in the same row are of the same thickness and the same depth; that those in adjoining rows are so set as to break joints by a space of not less than two inches, and that when thoroughly rammed they will be brought to the exact grade, and give the desired form to the finished surface, making joints generally one-half inch in thickness, and at no point exceeding one inch in thickness."

From this it appears that the foundation course of gravel is to be six inches deep, when compacted, that it is then covered with sharp washed paving sand to the "requisite depth," and completed to grade by the blocks, laid in a certain manner, which is clearly defined, excepting as to the intersections. The clause, recently introduced, requiring the rows at intersections to make "an angle of 45° with the intersecting roadways" may refer to either of two directions at right angles to each other, one of which is good, being normal to the lines of travel around a corner; the other

bad, being parallel to the path of the wheels. Yet samples of both kinds are to be seen in some recent city work.

To determine what is to be understood by the "requisite depth," we must know the size of the blocks; which, for granite, are required to be:

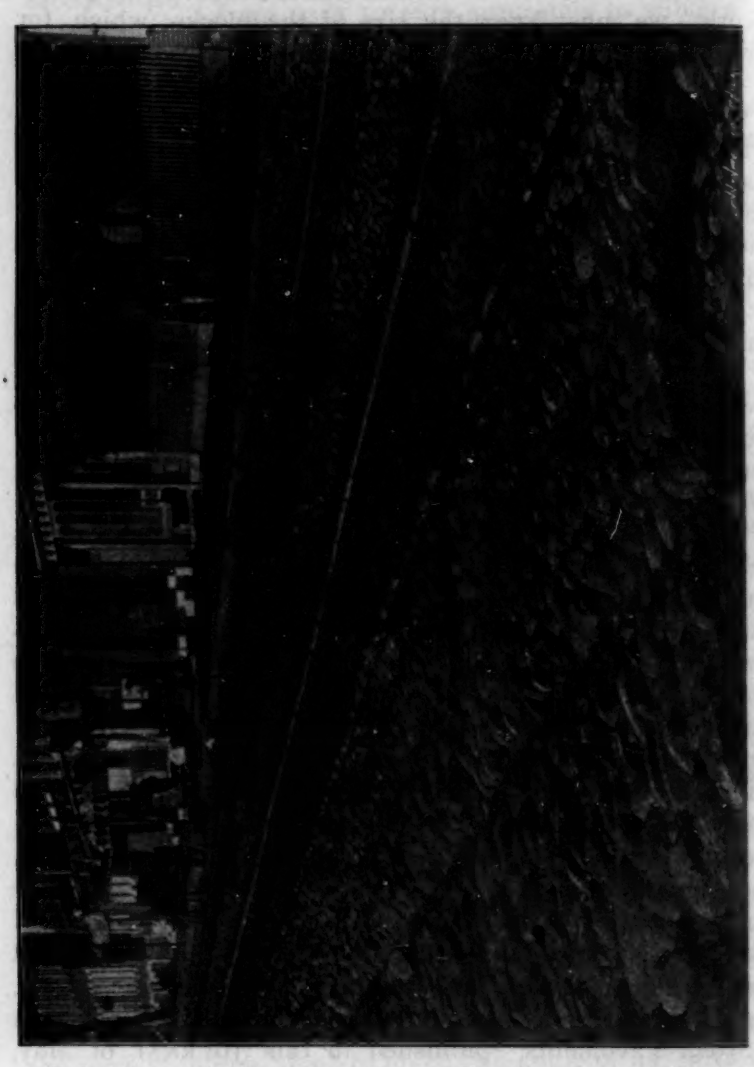
"From 6 to 7 inches in depth, 3½ to 4½ inches in width, 8 to 12 inches in length, faces not warped, straight, free from bunches, depressions and inequalities exceeding one-half inch. The faces shall meet at right angles, and the corresponding dimensions of opposite faces shall not vary more than one-half inch, and no stones shall measure less than the above-named lowest figure."*

This will give for the bedding course from two to three inches, depending upon the depth of the paving blocks.

Viewing this structure then from an engineering standpoint, we have a bed of, at most, nine inches in depth, composed of material whose elements are incoherent and surmounted by a flat arch of voussoirs, or blocks, between which there may be joints of from one-half to one inch—while for abutments there are curbs, it may be eight inches wide on top, twenty-four inches deep and projecting five inches above the surface of the roadway. This structure is subjected, not to a uniformly distributed load, but to a succession of shocks, blows and vibrations from very variable forces, applied at any or every point of the surface, and at times when the foundation and subsoil may be saturated with water or upheaved by frost, for in most cases the pavements are not impervious, as they should be. The effects of frost in breaking up the continuity of such a surface are very great, but there is not time now to consider them. Already there is too much of detail, and yet I ask your indulgence for a few words as to the wearing surface. I shall not go into the subject of its conflicting and varied requirements, nor the material best adapted to meet them, as this ground has already been covered in my paper on "Street Pavements," published in this JOURNAL of May, 1877, but I desire to emphasize the fact that, as before said,

* Section 9, of Specification for Paving with Granite, etc.

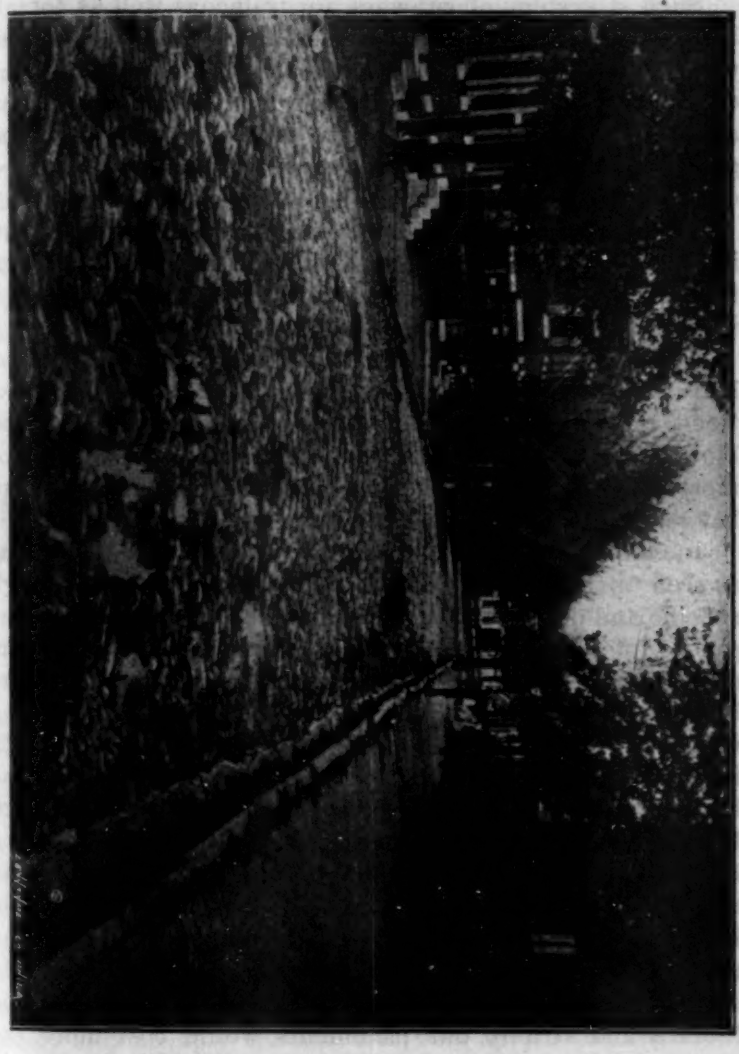
the joint is the weakest part of the surface, and, of all directions for the joints, that which is longitudinal or parallel to the line of traction, is the worst.



View of Rut-worn Street Pavement, 34th and Woodland Avenue, opposite University of Pennsylvania.

It follows, therefore, that the smaller the number of joints, and especially of longitudinal joints, the better, yet the pleas for their existence are based upon facility for handling

the material, foothold for the horse, and facility of removal. But pavements ought not to be laid with the expectation of having them broken into by every kind of service, as for



View of Street Pavement, Thirty-eighth and Warren Streets, West Philadelphia.

gas, water, electricity, sewage, heat or power. It is feasible to provide for these various conduits, without constant irruptions into the pavements. Elsewhere they are laid

under the sidewalks, or in subways provided for the purpose, where they are readily accessible for connections or repairs. Why not here?

Such a system of subways for traffic, as well as for all kinds of municipal service, should form the basis of a comprehensive plan for improving the physical condition of our city; then would permanent pavements become a possibility, and, as a consequence, the value of real estate would be greatly increased, and the revenues of the city be augmented correspondingly.*

But since we have not yet seen fit to require such an improved state of civilization, let us return to the consideration of our attempt to better our condition by the general introduction of the granite or other block pavement.

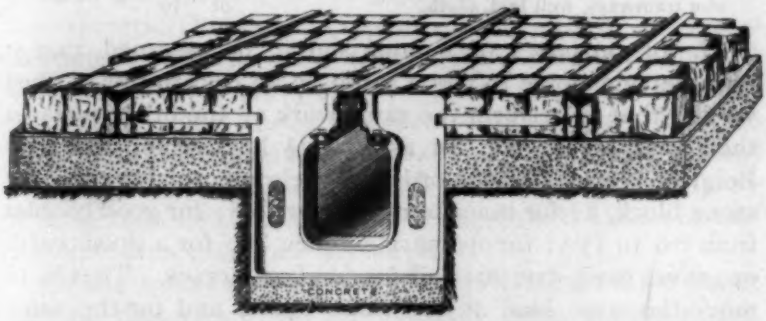
According to the specifications, these blocks should be laid in rows at right angles to the curbs, except at intersections, and the joints should overlap at least two inches. The blocks should not be less than eight inches in length nor more than twelve, and likewise the widths are restricted to between three and one-half and four and one-half inches.

In comparing these and other limitations with the results as seen upon our streets, we must conclude that although specific and definite, they were intended to serve merely as guides to indicate the approximate positions and dimensions, as well as character of the materials used, for there has been great liberty taken in their interpretation. As a rule, such discretion has been exercised wisely and with improved results, especially in the matter of laying the longer axis of the stones at an angle of about 45° to the curb lines, within the squares, as has been done generally on Franklin Street, instead of at right angles; and of permitting the length of the blocks to exceed twelve inches, reaching, in some instances, to nineteen or twenty, thus reducing the number of longitudinal joints and increasing the inertia of the block. If the specifications are to be interpreted literally and strictly, our pavements would cost more, the contractors would be obliged to bring suits for their money

* Vide p. 8, Report of the Commissioners for District of Columbia for 1885.

and the roadway would not be as good in some particulars. I believe, however, that the specifications should be amended to permit greater latitude, and then be more rigidly enforced. But no specifications can provide good pavements on poor foundations, or when the surface may be torn up almost as soon as it is laid, to repair a defective sewer or make a house connection. These are inherent defects which may be and should be removed.

The foreigner visiting America, on being asked what impressed him most forcibly, replied, "the miserable pavements," while the American in his tour through the chief cities of Europe, is compelled to respond to the same inquiry, "the excellent condition of your streets." The visiting engineers and others who attended the Paris Exposition this



summer all concede the truth of the comparison, and are convinced that better pavements are not only possible but necessary, and far more economical. What constitutes the difference? It is to be found in both the foundation and the wearing surface. Abroad, the former is generally a monolithic arch of concrete, laid in hydraulic cement, from six inches to one foot or more in thickness; the latter, a surface either without joints, except where rails are laid, or with very close joints between stones, well bedded in concrete, and rendered impervious to water. These pavements are easily and cheaply cleaned, and cost very little for maintenance.

Again, looking at the surface covering from an economic standpoint, let us see how the power required to move a

given load is affected by the resistances of the various kinds of pavements.

The resistance to traction caused

By sand is	$\frac{1}{5}$	or 20 per cent. of the weight of the load, or	400	pounds	per	ton.
" gravel it is	$\frac{1}{10}$	or 10 per ct. of the weight of the load, or	200	"	"	"
" an ordinary earth road it is	$\frac{1}{10}$th	" " or	200	"	"	"
" hard, dry clay or earth,	$\frac{1}{20}$th to $\frac{1}{30}$th	" " or	100 to 66	"	"	"
" cobblestones, ordinary,	$\frac{1}{8}$th	" " or	250	"	"	"
" good " small size,	$\frac{1}{15}$th to $\frac{1}{30}$th	" " or	133 to 66	"	"	"
" ordinary macadam,	$\frac{1}{25}$th to $\frac{1}{35}$th	" " or	80 to 57	"	"	"
" best French "	$\frac{1}{50}$th	" " or	40	"	"	"
" ordinary stone block,	$\frac{1}{25}$th,	" " or	80	"	"	"
" " Belgian "	$\frac{1}{40}$th,	" " or	50	"	"	"
" well laid " "	$\frac{1}{60}$th	" " or	33	"	"	"
" asphalt in sheet form,	$\frac{1}{133}$d,	" " or	15	"	"	"
" smooth granite trams,	$\frac{1}{180}$th,	" " or	12	"	"	"
" iron tramways, well laid,	$\frac{1}{200}$th,	" " or	10	"	"	"

If, for purposes of comparison, it be assumed that it requires one horse to move a ton on an iron tramway, then we find that to perform the same work on the other surfaces there will be needed, for asphalt $1\frac{1}{3}$ horses; for well laid Belgian block, $3\frac{1}{3}$; for ordinary Belgian, 5; for ordinary stone block, 8; for macadam from 5·7 to 8; for good cobbles from 6·6 to 13·3; for ordinary cobbles, 25; for a good earth or gravel road, dry, 20; and for sand, 40 horses. That is, to move the same load at the same speed and for the same length of time, with the same fatigue to each horse, requires, for *ordinary cobble stones 25*, and for *stone block pavements 8 times the number of horses necessary for iron trams*, while for asphalt only $1\frac{1}{3}$ are required. The great economy of smoothness, therefore, becomes at once apparent, but it is evident that, as in all lines of transportation, the greatest resistance regulates the load over the rest of the route, unless there be auxiliary power, so the continuity of the surface should remain unbroken by any other grade of material which would increase the resistance. It is estimated that if New York were paved throughout with asphalt, "the traffic that now costs $15,000,000, would be done for a fraction of that sum," and that at least $1,000,000 more could be saved in repairs on vehicles and for horses annually.*

* *The Manufacturer*, March 1, 1889.

Instead of reducing the number of horses, however, as a matter of fact and in accordance with the general maxim that *facilities beget traffic*, their number would be greatly increased, because of the real pleasure derived from riding over comfortable pavements. This ability to move readily over any part of the surface instead of following in well defined grooves as now, would also have the effect of greatly reducing the rates of fare by the establishment of other lines. Thus, in London and Paris the fares are much lower than in American cities for municipal traffic, while for general traffic, outside of the cities, our railroad rates are far less than those abroad.

A few remarkable facts concerning the increase of traffic and reduction of rates in London will bear repetition. Just prior to the opening of the underground railway, the London General Omnibus Company carried about 40,000,000 passengers annually, and the fare was seven cents. In consequence of the competition of rail and tramways the average fare is now about four cents (two pence) and the number of passengers has increased to 75,000,000 for each of the companies. The average cost to the omnibus company is three and one-half cents, and it pays twelve and one-half per cent. dividends from its surplus.

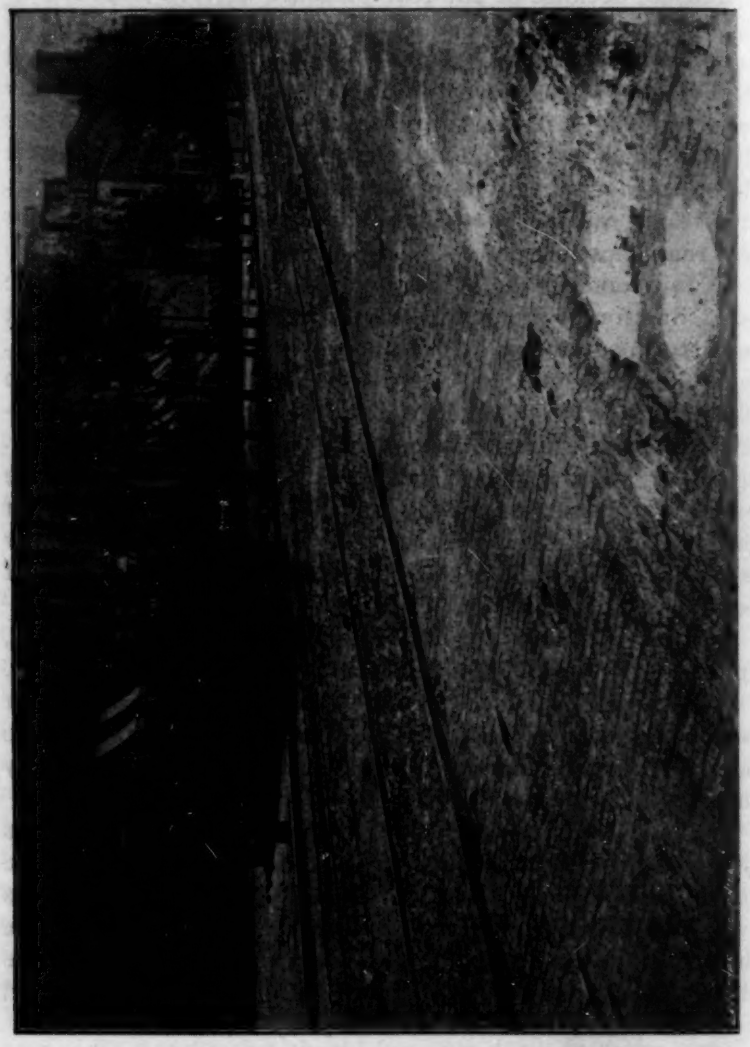
On the tramways the average fare is about three cents, and the cost about two and one-half cents per passenger.

The normal increase in traffic has been at the rate of ten per cent., and the total increment in twenty years was 470 per cent., while in the same period the population only increased thirty-six per cent.

On the London stages the fares are modified according to the distance, and will average in some localities only one cent per mile. The seating capacity of the omnibus is twenty-eight, or twelve inside and sixteen on top. They are drawn by two horses. In Paris some of the stages have three horses abreast, but there the rolling stock is larger and heavier.

The Paris General Omnibus Company make and repair their own vehicles, and in this service over 600 men of different trades are employed. Their wages in 1888 amounted to upwards of $268,000.

There are 1,600 vehicles of different models. Of these 1,000 are for passenger service in Paris, and they make a daily run of 55,800 miles, or about fifty-six miles each. They

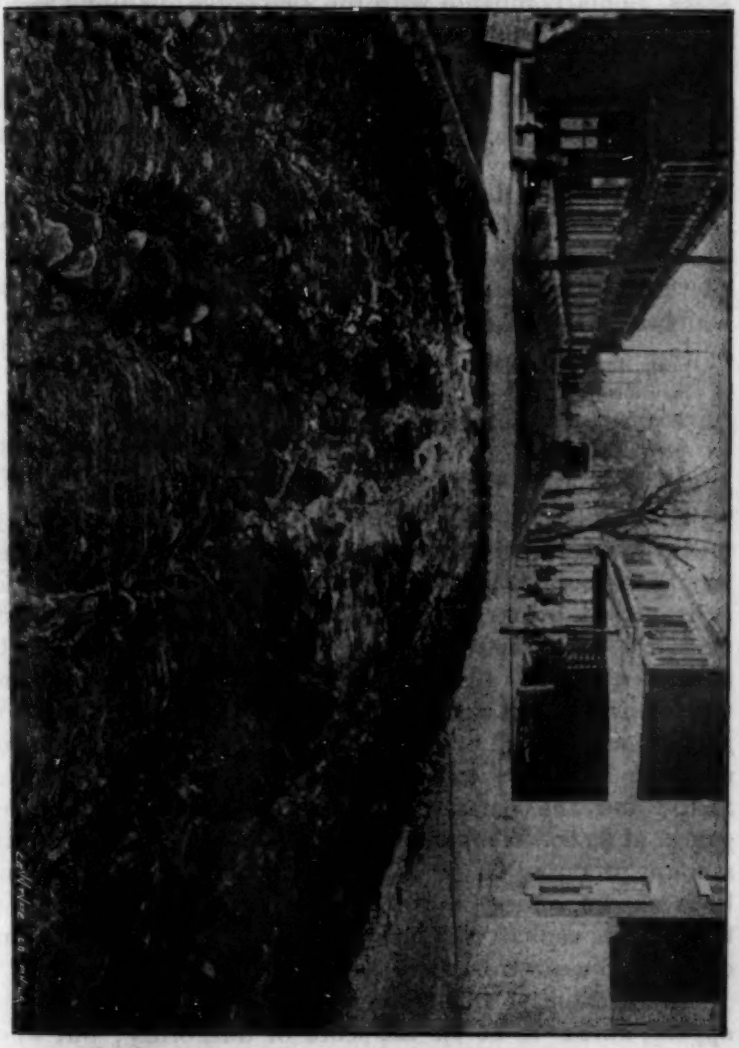


Asphalt Block Pavement, Spring Garden Street, West of Eighteenth Street.

all have an imperial or upper deck, to which ladies are admitted when riding on the tram-cars, three-horse coaches or the new two-horse patterns.

The number of passengers carried in 1888 was 181,215,288.

A two-horse omnibus of class 1 will carry thirty persons, and to prevent overcrowding as well as to insure a seat,



View on Mifflin Street, below Front, looking West.

numbered checks are given to passengers at stations on the route. These are collected by the conductor on entrance, and when all the seats are filled, a placard marked "Com-

Asphalt Block Pavement, Spring Garden Street, West of Eighteenth Street.

plet" is exposed and kept up until some one alights. A three-horse omnibus will carry about forty-four passengers seated, while our street cars have a capacity of twenty seats. This, compared with the two-horse omnibus, would show an economy in favor of the latter of fifty per cent.

We have thus briefly reviewed the fundamental defects of pavements, and the benefits accruing from their improved condition. Let us now look for a moment at the relative cost.

In their report to his Honor, the Mayor of this city, in 1884, the Board of Experts appointed to examine into the condition of our street pavements, say:

"The cost per square yard of the standard pavements which we recommend, is as follows:

Seven-inch granite blocks on concrete foundation, ...	$3 65
Six-inch " " " gravel "	2 60
Sheet asphalt on concrete foundation, ...	2 25
Asphalt block on " "	2 90
Asphalt block on gravel "	2 10 "

They further estimate that at that date there were 535 miles of streets paved with cobblestones, containing in round numbers 9,000,000 square yards. Of this distance 203 miles is traversed by street railroads. Then follows their estimate for repaving, which aggregates $21,095,000, to be spent at the rate of say $2,000,000 per annum. In making up this estimate it was suggested that 1,000,000 yards be of granite on concrete at $3.65; 1,100,000 of sheet asphalt on concrete at $2.25; 300,000 of asphalt block on gravel at $2.10; and the balance or 6,000,000 yards of granite on gravel at $2.60. This is over seventy per cent. of the entire amount proposed to be covered by a surface which, as has been shown, offers more than five times the resistance to traffic than asphalt; is very permeable, has a weaker foundation and costs thirty-five cents more per square yard.

The wisdom of this recommendation does not therefore appear, unless it be on the score of durability; but when the cost of maintenance of these two kinds of pavement is compared, there is so little difference as to leave virtually no choice, for whilst the improved asphalt surface will wear

down more rapidly than granite, the latter will require more labor in consequence of its defective foundations.

Since this report was submitted the use of vitrified brick has become quite popular, and for light traffic has given some very satisfactory results.

In this city it has been extensively introduced in West Philadelphia and other districts, where it is laid upon a nine-inch bed of fine gravel covered by two inches of "clean bar sand."

A brick pavement of this description has been in use in Charleston, W. Va., for sixteen years, and is said to have cost nothing for repairs or maintenance. As the joints are laid close and filled with cement, it makes an impervious covering at a low cost and provides a good wearing surface when the bricks are of good quality.

The cost of new pavements in the outlying districts could be materially reduced, by keeping the grades of the streets or roads a few inches below the approved city or district grades, so that the original road surface, whether it be of macadam, gravel or even cobblestones, might be used for the foundation of the subsequent wearing surface,* thus avoiding the removal of the original surface and the preparation of a new foundation.

The best disposition to be made of existing cobble and rubble pavements, would be to crush the stones up for the concrete to be used in repaving.

THE FINANCIAL QUESTION.

After all, when we have determined what is the best and most economical kind of a pavement for given conditions, we are confronted with the more important question of providing the means to carry on the work.

Here the way is hedged in by laws and ordinances, limiting the power to raise money and prescribing the manner of paying for the work when done, to such a degree as to constitute a serious obstruction to any public work of this kind when undertaken on a scale of so great magnitude.

* This idea was first suggested by the writer, in designing a revised plan for the streets of Superior, Wis., in 1882.

To *borrow* the money, as has been suggested, is merely to put off the evil day upon our children, who will inherit the worn-out pavements with their cost. As well might we borrow money for our raiment and bequeath to posterity the bills with the tattered garments.

Again, to pay for work done by assessment bills on the adjacent properties, embracing rich and poor alike, is in many cases a great hardship and is almost equivalent to giving to the contractor authority, in the name of the city, to turn the artisan, who may be buying by instalment, out of doors.

To raise money by increasing the tax rate is undoubtedly the best plan, but even this appears unjust, as throwing the burden, of the improvement mainly upon holders of real estate, who pay their pro-rata in the taxes and are then levied upon for assessments in addition.

Is there no way, under the Constitution, whereby a special improvement tax could be collected from all classes of citizens? This is a question for Councils, and not for us to consider. If feasible, it would distribute and lighten the burden, the funds would be provided regularly, as required, and the streets of this city would be made to fulfil their purposes of providing means of communication with a minimum of resistance and cost. It is the honest policy of "pay as you go" and is the cheapest in the end, provided in every case that the work be properly designed and faithfully executed.

The city of Washington is far in advance of any others in regard to its pavements, since it is not restricted in its finances and its municipal works are under the direct supervision of an engineer commission, which has given much attention to the problem of pavements. It has already about eighty-one miles of streets covered with asphalt, and it has also introduced extensively the grooved girder rail so universally used on the continent.

STREET-CAR TRACKS.

The tram-ways, or street-car tracks, as laid in our cities, are a continual source of trouble and give unsatisfactory

results. But nothing else can be expected from a structure whose foundation is an unpreserved, and frequently an unseasoned, vegetable substance. To lay a side or centre-bearing, flat, iron rail upon a wooden stringer, having a continuous vertical joint on either side to admit water, and forming a rut for wheels, is unscientific and destructive to both the rolling stock and the way. Moreover, it induces traffic to follow the lines of the trams instead of permitting it to take any part of the pavement with equal facility. As a rule the rails are warped in both directions and the counter-sunk heads of the spikes are worn off, leaving in many places a sprung rail and depressed joint, which produces the destructive oscillations so noticeable on many lines.

The form of rail used in New York is even worse than here. It is so bad that the last mayor felt obliged to recommend its removal in the strongest language.

The rail which is found to fulfil the requirements of street travel best abroad is a grooved girder-rail, six inches deep, with a bottom flange four and one-half inches wide. The head is about four inches wide, of which two inches are for the tread and one inch for the groove.* This slight channel is ample to guide the cars and has no effect upon other vehicles, either in crossing or following it.

To form practically a continuous rail, the ends of each are bevelled at an angle of 45° so as to overlap, and as they are firmly bedded on a concrete base and filled up with concrete or asphalt, they are very durable and remarkably smooth, forming a delightful bearing surface, in strong contrast to our own cheap and unmechanical makeshifts.

Boston and Washington have already introduced this form of rail, and the Highway Commissioner of New York is on record as saying: "I have made up my mind to refuse permits in every case unless the railroad companies will agree to lay such rails as I require. The rail that I shall insist upon is a grooved rail, with an opening $\frac{1}{16}$ of an inch

* Samples of this rail were kindly furnished by the Johnson Street Girder Rail Company of Johnstown Pa., where it is now manufactured.

wide. No wagon wheel can be caught in this rail, and it can be crossed at any angle with safety. I propose to adhere to the position I have taken until I am overruled by the Courts."

A similar resolution on the part of our local authorities would give a result which would be beneficial to the street-car companies, to the public and to the city.

THE FOOTWAYS.

The sidewalk nuisance is another point upon which much might be said, but a long-suffering community seem to regard the use of the sidewalk for storing and displaying goods or empty boxes as either a privilege or a necessity, and prefer to take to the roadway rather than wait until a dray-load of cotton, sugar, china or other merchandise can be discharged by skids into the front doors of the stores or warehouses. While the majority of our streets are sixty feet wide, giving thirty-four for roadway and thirteen on either side for pedestrians, nearly half, and in many places more than half, of this is obstructed by projecting steps, signs, showcases, gratings, trees, fire-plugs, telegraph poles, cellar-doors, lamps and letter-boxes, carriage-blocks, hitching-posts, news and fruit stands and an occasional pump, to say nothing of the contents of the stores which are exposed for sale daily on the pavements.

It may, therefore, appear to be a restriction of personal freedom to learn that in London trucks and wagons are not allowed to back up against the curb and to place a plank across the pavement; packing cases and barrels are prohibited under the strictest police regulations from being placed on the sidewalk. Neither is it permitted to dump coal, unload barrels or any articles whatever upon the streets between 9 A.M. and 6 P.M., but all merchandise is required to be handled directly by cranes attached to the buildings or warehouses and reaching to the drays in the streets, or in bags or baskets. Thus the latter are preserved for the legitimate purpose of transit.

In selecting my subject, it was with the intention of making a general comparison of some of the various munic-

ipal improvements at home and abroad, such as the sewers, docks, city trams and conduits, but the great and urgent need of our pavements and the belief that we are not proceeding in such a way as to obtain the best results for the money expended, has induced me to confine my attention mainly to this latter subject. When it is remembered that to replace the existing cobble and rubble pavement will cost from $20,000,000 to $25,000,000, it becomes a serious matter, and it is important that we should start right. If this money were raised by loans, the interest on it would be $1,000,000, at four per cent., and were it not for our present unfortunate inheritance of debt, thirty-five per cent. of our income from taxes, or nearly *four and a half million of dollars* annually might be applied to public improvements, without increasing the rate one cent.* Yet it is seriously proposed to perpetuate this evil in an aggravated form.

In conclusion, let us now gather up the threads of this mottled fabric and fix in outline the pattern it has revealed.

We have seen that our pavements, as laid, are radically defective, being structurally weak and ill adapted to their purposes; that the foundation is inefficient and the surface covering in most cases such as to oppose far more resistance to traffic than is necessary; that it involves a waste of power and an excessive wear; that the constant breaking into the streets for repairs to sewers, for laying mains and for house connections is a serious evil that should be avoided.

That the form of tracks used for tram-rails and their foundation are alike inferior to modern requirements and far behind the present state of the art of street railway building.

That the specifications are so worded that a strict interpretation of them would either prevent any one from bidding or greatly increase the price of the work.

That the method of paying for these improvements by assessment bills is obnoxious and an obstacle to the passage of ordinances for the proper paving and grading of many of our streets.

* The assessed value of taxables for 1889 is $688,713,518, at $1.85 per $100, gives for the revenue from this source $12,646,199.75.

That a system of subways should be constructed by the city for the various kinds of municipal service, and be rented to the private corporations desiring such privileges. The revenues from these rentals as well as the reduced cost of cleaning and maintaining the pavements would abundantly compensate the city for the cost of the work.

That the use of the sidewalks for storing, exhibiting and packing goods constitutes a serious nuisance. That the grades of new streets and avenues should be kept below the final surface to serve as a base for the subsequent pavement, thus saving large sums for excavation and reforming of foundations.

That the wearing surface should be as free from joints as possible, especially if they are longitudinal, and that the smoother the surface the larger the traffic will become.

The mere recital of these defects is sufficient to suggest their appropriate and manifest remedies, which it rests with us, as citizens, to apply.

They embrace three distinct lines of action: (1) the preparation of a systematic plan for streets and conduits under engineering supervision; (2) the formulation of a more equitable plan for raising the means wherewith to pay for extended improvements, and (3) provision for the rapid and thorough execution of the works.

Having now reviewed briefly what may be called the theoretical side of the subject, let us look at some of the practical results obtained at home, as well as abroad, correcting our impressions and judgment by means of the comparisons.

This series of fifty-four slides has been carefully prepared to show the various types of pavements and their ordinary defects, from the best to the worst, including sheet asphalt, brick, stone block, asphalt block, cobble and rubble, with curbs, trams and the various features of street obstructions, broken sewers and machinery for sweeping.*

NOTE.—About thirty of the views were selected from the

* The JOURNAL is indebted for the use of the foregoing specimen illustrations of street pavements in Philadelphia to the Philadelphia *Sunday Mercury*, which published an abstract of Prof. Haupt's lecture.—COM. PUB.

streets of Philadelphia which were contrasted with those of London, Paris, Amsterdam, Newcastle, Vienna, Stratford-on-Avon, Rome and Pompeii.

PHILOSOPHY OF THE MULTI-CYLINDER, OR COMPOUND, ENGINE; ITS THEORY AND ITS LIMITATIONS.*

By Robert H. Thurston, Ithaca, N. Y.

Were it possible to construct a steam-engine of which the theory should be purely thermodynamic, an engine in which the only waste of energy should be that known as the necessary thermodynamic loss, its theory would be most simple and most satisfactory. The efficiency of the engine and the quantities of heat, steam, and fuel demanded for its operation at a given power, would be simple functions of the physical properties of the steam and of its ratio of expansion. The engineer, in constructing its theory, would only concern himself with the quantity of heat imported into the machine, the temperatures of the initial and terminal portions of the expansion line, and the relation of initial to back pressures. As was well stated by Rankine, a generation ago, nearly, the essential facts are the magnitudes of the pressures and volumes of the steam and the extent of adiabatic expansion, and it matters not whether the engine be one of a single cylinder or a multi-cylinder engine of indefinitely extended complexity. For this, the ideal case, as the writer has been accustomed to call it, the indicator diagram represents precisely the amount of transformation of heat-energy into mechanical work, and the ratio of its measure in units of work to the mechanical equivalent of the total quantity of heat-energy supplied to the engine, while doing that work, is the measure of the

* Presented at the Twentieth Meeting of the American Society of Mechanical Engineers, held in New York, November, 1889. Revised by the author for publication in the JOURNAL, and printed by permission from advance sheets of the Society's *Transactions*.

efficiency of the engine; as it is of the thermodynamic efficiency of the working fluid. The thermodynamic efficiency, the dynamic efficiency of the machine, and the total efficiency of the engine are here identical.

To ascertain how much heat, steam, and fuel are demanded by such an engine for the performance of work, it is only necessary to measure the quantity of work done by the steam upon the piston, as shown by the indicator, and to divide this quantity by the energy received by the engine from the boiler; the quotient is the efficiency of the engine. As the operation of the engine approaches more nearly the conditions of best effect, the magnitude of this measure of efficiency approaches a limit which is expressed by the quotient of the range of temperature worked through to the absolute temperature of the working fluid at entrance into the engine. Were all heat received completely utilized and the full thermodynamic equivalent realized in work performed, the quantity of steam demanded per hour and per horse-power, under the conditions now common in practice, as to initial and final temperatures, the engine being assumed perfect, structurally, would be about two and a half pounds, for efficiency unity, or not far from ten pounds for the best real cases, no wastes occurring. The excess of the actual consumption of fuel, in the best engines, above this last figure measures the sum of all wastes in real engines due to imperfections other than of thermodynamic cycle. Thus, the best work of the Corliss mill-engine may be taken as about sixteen pounds of steam per horse-power and per hour, where the thermodynamic efficiency is as just assumed, about twenty-five per cent. The wastes amount, in this case, therefore, to about six pounds per horse-power and per hour, or sixty per cent. of the ideal consumption. This comparison is easily made by a method first presented in full by Rankine, a generation ago, and which enables the thermodynamic efficiency to be easily computed for any given case.* Examples will be presently given of its application.

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* *The Steam-Engine and other Prime Movers*, pp. 383–412.

The wastes of the steam-engine comprehend two principal classes: the external and the internal wastes; and these latter are of two distinct kinds. We may classify them thus:

(1) External wastes; consisting of those losses of heat without transformation which are produced by the conductivity and the radiating power of the materials of which the heated parts of the engine are composed. Heat which might otherwise be utilized by conversion into mechanical energy, is conducted or radiated to the adjacent parts of the engine and to surrounding objects.

This form of waste is of small amount, comparatively, and can readily be kept down to an unimportant proportion of the heat supplied from the boiler by properly covering exposed parts of the engine with non-conducting covering. Five per cent. should probably represent as large a percentage as is to be reasonably expected in good practice.

(2) Internal wastes; consisting of two parts:

(*a*) Thermodynamic, unavoidable, losses of heat rejected at the lower limit of temperature of working fluid;

(*b*) Wastes by internal conduction and storage of heat, followed by later rejection with the exhaust steam.

To these are to be added:

(3) Wastes of mechanical energy.

Of these losses, the first, (*a*), represented by the fraction, as a minimum, $\frac{T_2}{T_1}$ of the heat supplied, is, for any given set of initial and final temperatures of working fluid, a fixed and irreducible quantity, and one which measures the defect of efficiency of the perfect engine working between the given temperatures. The second, (*b*), is a quantity of variable amount, capable of amelioration by one or all of several known expedients, and reducible from the enormous proportion observed in small and ill-designed or badly constructed engines to a very moderate amount in large engines of good type. The last item, (3), is one which is seldom large in good constructions, as compared with the magnitudes, at least, of the other kinds, and may in some cases, by careful design, good construction and skilful manage-

ment, be brought down to less than five per cent. in non-condensing and to perhaps ten per cent. of the total energy in condensing engines of simple forms and high mean working pressures. The unavoidable thermodynamic waste is rarely less than seventy-five or eighty per cent., and the internal wastes by conduction and storage with subsequent rejection, by cylinder or internal condensation, as it is customarily called, and by leakage, range from ten per cent., as a minimum, perhaps, to twenty-five or thirty per cent., in good engines, to fifty per cent., in many cases, and even to much more than the latter proportion in exceptional cases. It is this which constitutes, ordinarily, the great source of loss and inefficiency of the real, as distinguished from the ideal engine. Leakage, in well-built engines, may be neglected as unimportant; but internal condensation is usually both serious in amount and extremely difficult to check effectively.

Since it is easy to prevent serious losses by external transfers of heat, by leakage, or by friction of engine, and since, as is well understood, the thermodynamic waste is unavoidable, and for any given case unalterable by the engineer, it is obvious that the direction in which he must look in his endeavor to further improve the economical performance of the engine, is that which leads towards the reduction of internal wastes by cylinder condensation.

The method of internal waste by condensation, as is now well and generally known, and as is now shown by all authorities,* consists in the absorption and storage of heat in the metal constituting the internal surfaces of the cylinder, at the commencement of the stroke, and to an extent which is determined by the difference of temperature at the moment existing between the prime steam and those surfaces which have been exposed, during the exhaust stroke, to the cooling influence of the comparatively cold steam passing into the condenser or into the atmosphere. This stored heat is, later, rejected during the terminal portion of

* See especially the works of Clarke, Hirn, Isherwood, and Cotterill, and more recently of Dwelshauvers-Dery.

the expansion period, and during the succeeding exhaust stroke, to the mass of steam exhausted, in its turn, at the opening of the exhaust passages. The quantity so wasted varies with the weight of steam worked thermodynamically each stroke, with the area of surface exposed to this action, with the period of exposure, and with the range of temperature worked through during the cycle. It is thus always an increasing quantity when the ratio of expansion is increased, and as the size of engine doing a given amount of work is increased; it is diminished by increasing engine-speeds and by any expedient which reduces the storing capacity of the interior of the cylinder. Since it is always an increasing function of the ratio of expansion, there always will be found, in any engine and under any given conditions of operation in other respects, a point beyond which further increase in the magnitude of that ratio will result in a loss by cylinder condensation greater in amount than the gain due to extended expansion, a circumstance which has been now known, for many years, as placing an early limit to the expansion of steam, and to the gain to be anticipated as a consequence.*

The method of variation of this waste was qualitatively determined by Clarke about 1850, was roughly gauged by him, both as to magnitude and as to its effect in limiting the ratio of expansion; was quantitatively investigated by Hirn and by Isherwood afterward, and was finally made the subject of an investigation, under the supervision of the writer, by Messrs. Gately and Kletsch, on a plan sketched out by the writer some years earlier,† in which it was endeavored to ascertain with some degree of accuracy the method of variation of the waste with variation of each of the essential conditions affecting and determining it. The result of this research in brief was to show that the waste varied, in the cases studied, sensibly as the square root of

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* *Trans. Am. Soc. Mech. Engrs.*, 1882, *et seq.*; *Trans. N. Y. Acad. Sci.*, 1882; *Brit. Assoc. for Adv. Sci.*, 1884; this JOURNAL 1882, *et seq.*

† This JOURNAL, Oct. and Nov., 1885. *Trans. Am. Assoc. for Adv. Sci.*, Ann Arbor Meeting, 1885.

the ratio of expansion, and as the time of exposure, and was subject to a very slow decrease as the pressures adopted increased, the engine being worked condensing; decreasing about twice as rapidly, the condenser being thrown off.*

Variation with ratio of expansion was also capable of being expressed with great accuracy by an hyperbolic expression, the product of areas of surface exposed up to the point of cut-off and the percentage of condensation being found sensibly constant. Under ordinary working conditions, the steam pressure being about sixty pounds per square inch, by gauge, the cut-off at one-third, and the speed of piston 554 feet per minute, and of rotation sixty-eight revolutions, the condensation was about one-third, or the equivalent of fifty per cent. of the total consumption of a similar engine having a non-conducting cylinder, and thus free from this waste. Reduced to quantity of steam and of heat wasted, per square foot of surface exposed to point of cut-off, per minute of exposure, and per degree of range of temperature between prime and exhaust steam, Professor Marks finds the co-efficient to be 0·02 pounds, or 18 B.T.U., nearly, a result closely confirmed by the investigations of the same author, taking Hill's experiments for comparison, and also corroborated by the later work of other investigators.

These facts and laws being established, it becomes possible to determine the behavior of steam entering any given cylinder, and its method of working and of waste in any engine. Common experience, as well as theoretical considerations based upon the investigations already made, prove that it is impossible to expand steam in the ordinary single-cylinder engine with satisfactory gain of efficiency, beyond a point variable with the conditions assumed, but which may be roughly taken as not far from that giving a ratio of expansion equal to about one-half the square root of the steam pressure, measured from vacuum for the condensing engine of common type, or as measured by gauge for the

* The proportion thus wasted in these experiments were from $0{\cdot}18\ \sqrt{r}$ to $0{\cdot}19\ \sqrt{r}$. The writer takes $c = 0{\cdot}2\ \sqrt{r}$ in later work.

non-condensing engine. The waste by internal condensation increasing as the point of cut-off is shortened up, the loss, after a time, compensates the gain by increased expansion, and a point of maximum economy is passed at a very early stage for the older types of engine and later, but still at a comparatively low value of the ratio of expansion, for modern engines. For example, the old beam engine, such as was used in American rivers, or in the coast trade, a generation ago (1850), with steam at twenty-five pounds by gauge and a low piston speed, had a ratio of initial to back pressure plus friction of about 8 to 1; but its best ratio of expansion for efficiency of fluid was about 2 or 2½. The same type of engine, later, with twice the pressure per gauge, had values of these two ratios of about 16 and of 4 or 5 respectively. The ratio of expansion for maximum efficiency of working fluid was thus but about one-fourth that which thermodynamic theory, unqualified, would dictate. As engines have been improved this discrepancy has been reduced, but it still remains, with the best of engines, considerable.

The amelioration of wastes thus becomes an important matter. It thus happens that the efficiency and economy of operation of the single cylinder, the "simple" engine, is at all times limited by this very serious internal waste, and the question which all engineers since Watt have been endeavoring to solve, is: In what manner may we best proceed to eliminate or ameliorate this loss. The three methods which have been found advantageous, and, in special cases, fairly effective, are:

(1) Superheating.
(2) Steam jacketing.
(3) "Compounding."

It is evident that, if the steam can be introduced into the engine at such a temperature that the cooling action of the metal of the cylinder will not cause its condensation initially, and the stroke may be performed without condensation in consequence of doing work, no loss of heat from the cylinder can take place by re-evaporation; and if no such loss occurs, the waste of heat at entrance, in turn, by initial

cooling, will be reduced. Superheated steam, also, is a non-conductor and a non-absorbent of heat, precisely like the permanent gases. It is thus, also, less liable to this waste. But it is found in practice that superheating beyond a very moderate degree, perhaps 100° F., is inadvisable on account of risks of injury to engines and cost of repairs to superheater, which more than compensate its advantages. It has come to be regarded as an auxiliary in economizing, not as a remedy for interior wastes.

Steam-jacketing is another and a common partial remedy for this waste. By surrounding the steam-cylinder with the steam-jacket, it is possible to produce, in part, the effect of superheating; that is to secure dryer steam in the engine throughout the stroke. The amount of re-evaporation, during the period succeeding cut-off and up to the closure of the exhaust-valve, and the quantity of heat of which the cylinder is thus robbed, measures the amount of initial condensation and waste and the weight of steam which must be supplied in excess of the thermodynamic demand to compensate that loss. The effect of the addition of a steam-jacket depends upon the conditions of operation of the engines, largely, and may be productive of marked advantage, or under unfavorable conditions, of no important useful effect. With steam initially dry or superheated, the jacket is probably always decidedly helpful; but, with wet steam, it is of comparatively little value, even if not sometimes a positively wasteful adjunct. High-speed engines derive less advantage from its application than slow-moving machines; and compound, or multi-cylinder engines are less dependent upon it for economy than are simple engines. The saving effected in ordinary cases, by its use, may be taken as averaging about twenty per cent.; and about the same gain is attained by effective superheating within the usually practicable range. The two devices in conjunction may be expected, ordinarily in mill engines, perhaps, to give a gain of something like thirty per cent. as compared with the standard forms of unjacketed simple engine working with slightly wet steam. The addition of either expedient to the latter practice, if properly performed, con-

siderably increases the magnitude of the ratio of expansion at maximum efficiency of fluid. Where it would ordinarily be approximately equal to one-half the square root of the pressure, as above, it might become, with superheating or with steam-jacketing, a figure as much as thirty or forty per cent. higher; and both expedients together might nearly double the profitable ratio of expansion. The assumption is commonly made that the superheating is retained throughout the stroke and that steam-jacketing may be relied upon to keep the working charge dry and saturated throughout the stroke; but neither of these hypotheses, as employed in the theory of the engine, is practically correct.

"*Compounding*," or the use of the multi-cylinder engine, in which the steam exhausted from one cylinder is again worked in a succeeding one, is the most familiar of devices for extending the economical range of expansion and increasing the efficiency of the engine. The limit to the useful extension of the expansion of steam in a single cylinder is found to be determined by the magnitude of the wastes incurred in the operation of an engine of which the working cylinder is a good conducting material. Any method of reducing this waste of heat internally will enable the efficiency of the engine to be increased by further profitable extension of the ratio of expansion. Common experience with the best constructions, and considerations which need not be here reviewed, show that the engineer may reasonably expect, by good design, construction and management, to secure an economy of steam which is fairly measured by the following table, the ratios of expansion, r, taken being, for each case, those which give best results for a given engine: *

STEAM PER HORSE-POWER PER HOUR, AT BEST RATIOS OF EXPANSION IN BEST ENGINES.

r	3	4	5	6	7	8	10	12	15	20	25	50	75
lbs.	32	27	25	22	20	20	19	17	16	15	15	1·1	0·9
kgs.	15	12	11	11	9	9	9	8	7	7	7	0·5	0·4

and ten per cent. better figures than these have been actually reported in peculiarly favorable cases.

* "Several efficiencies of the Steam-Engine." *Trans. A. S. M. E.*, and this JOURNAL, 1882.

Assuming it to be possible to divide the waste by cylinder condensation and leakage by two or more, it is evident that the limit to economical expansion and transformation of heat into work will be set correspondingly further away. This is precisely what is done by the multi-cylinder engine. The internal wastes are reduced approximately to those of one of its cylinders, and the gross percentage of waste is made less in the proportion of this division. The heat and steam rejected as waste by internal transfer without transformation from the first cylinder, is utilized in the second nearly as effectively as if it were received directly from a boiler at the pressure of rejection from the first cylinder. In so much, therefore, as the pressure can be increased and the increase utilized by the addition of another cylinder, gain is secured. If the total ratio of expansion can thus be raised, under the best working conditions for each case, we will say, from four up to eight, we should hope to secure a reduction of coal consumed from two and a half, we will say, to two pounds per horse-power and per hour, which is about the average figure in good practice.

The practical questions thus meet the engineer: To what extent can this principle be availed of? What range of pressure and what ratio of expansion should be assigned to a single cylinder? and how many cylinders should be adopted to give best results with the highest steam pressure practicable for a specified case? Common experience aids in solving this problem by showing that the very best results are ordinarily obtained, in each class of multi-cylinder engine, when, the engine being properly designed for its work, the terminal pressure for the system can be economically made something above the sum of back pressure in the low pressure cylinder, plus friction of engine. This total may be usually taken, probably, at about eight or ten pounds above a vacuum. The latter figure will be here assumed.

The fundamental principles are now easily perceived. There are three main facts upon which to base our theory of the multi-cylinder engine. These are:

(1) *Economical expansion in a single cylinder has a limit, due*

to increasing internal wastes, which is found at a comparatively low rotio of expansion.

(2) *The method of expansion may be, for practical purposes, such as are here in view, taken to be approximately hyperbolic; the terminal pressure being something above that which corresponds to the sum of all useless resistances, and which may be here taken, as, for example, about ten pounds per square inch above a vacuum. The division of the initial pressure by this terminal pressure will thus give an approximate measure of the* desirable *ratio of total expansion for the best existing engines.*

(3) *All steam entering any one cylinder will be rejected,* as steam,* *into the succeeding cylinder, external wastes being neglected, and into the condenser; and the full amount of steam condensed at entrance by absorption of heat by the interior surfaces of the cylinder will be re-evaporated later, and will pass into the condenser or into the next cylinder, and heat transferred in the one direction, in the one process, will be transferred in precisely equal amount in the opposite direction in the other.*

This last point is a very important one, and is very easily established. The cylinder, when in steady operation, is neither permanently heated or permanently cooled; no progressive heating can go on, as it would, in that case, become heated above the temperature of the steam and become a super-heater; no progressive cooling can occur, since, in that case, the cylinder would become a condenser of indefinite capacity. It must, therefore, transfer to the next element of the system all the heat which it receives, assuming that external radiation and conduction may be neglected and that the Rankine and Clausius phenomenon of internal condensation, by transformation of heat into work, is ignored. It also further follows that the introduction of one or of many cylinders between the terminal element and the boiler does not, through cylinder condensation, affect the operation of the latter cylinder, however great that condensation may be, provided the operation of

* This the writer would denominate Hirn's principle. See a paper by Dwelshauvers-Dery in the *Bulletin de la Société Industrielle de Mulhouse*, October, 1888, on the theory of single-cylinder engine.

the added elements is effected by raising the steam pressure commensurately, leaving the final element of the series the same initial pressure as before. The total waste by this form of loss is thus evidently measured, in the case of the multi-cylinder engine, by the maximum waste in any one cylinder. If all are equally subject to this loss, the rejected steam of re-evaporation from any one cylinder, as the high-pressure cylinder, supplies precisely what is needed to meet the waste by initial condensation in the next; and so on through the series. Thus the use of a series of cylinders, in this manner, divides the total waste for a single cylinder, approximately, at least, by the number of cylinders; and it is in this manner that the compound system gives its remarkable increase of efficiency. As stated by the writer, many years ago, "The serious losses arising from condensation and re-evaporation within the cylinder, and which place an early limit to the benefit derivable from expansion, affect both types of engine, and so far as seems now known, equally;"* but the modern type permits the interception of the heat wasted from one cylinder, for utilization by its successor, in such manner that the total waste becomes, practically, that of the low-pressure cylinder alone. If any one cylinder wastes more than another, the total waste is, as above stated, measured more nearly by the loss in the most wasteful member of the system.

Thus the three principles, which have been above enunciated, give a means of constructing a philosophy of the multi-cylinder engine, which will meet the essential needs of the designer and of the student of its theory. The first principle shows that a limit existing to economical expansion in a single cylinder, the advisable number of cylinders in series may probably be determined, when that limit is ascertained, either by experiment, by general experience, or by rational theory and computation. The second principle shows that we may find a tentative measure, at least, of the desirable total ratio of expansion for maximum density, when the best terminal pressure for the chosen

* Vienna Report, 1873.

type of engine is settled upon. This total range is divided by the admissible range for a single cylinder, or, perhaps better stated, the total ratio is a quantity which should approximately equal the admissible ratio for a single cylinder, raised to a power denoted by the number of cylinders. Combining thus the two considerations referred to, we obtain a determination, probably fairly approximate, of the proper number of cylinders in series. The third principle permits an estimate to be made of the probable internal wastes of the series, and the probable total expenditure of heat and of steam, and a solution of all problems of efficiency for the compound engine, of whatever type.

The first step in the process is evidently the determination of the best ratio of expansion, under the assumed conditions of operation and for the given type of engine, for a single cylinder; then the best ratio of expansion for the series, all things considered, this study being made from the financial standpoint, as must be every problem which the engineer is called upon to solve. It is not the thermodynamic, nor the fluid, nor even the engine efficiency, which must be finally allowed to fix the best ratio of expansion; but it must be the ratio of expansion at maximum commercial efficiency, that which will make the cost of operation at the desired power a minimum for the life of the system.* The total ratio being settled upon, and that allowable, as a maximum, for the single cylinder, it is at once easy to determine the best number of cylinders in series. The first-mentioned ratio is that at maximum commercial efficiency, as just stated; but the second must be taken as that which gives the highest efficiency of engine, the back-pressure in that cylinder and the friction of the cylinder taken singly, being considered, together with its proper proportion of the friction of the engine as a whole.

Studying the method of distribution of wastes among the several cylinders of the multi-cylinder engine, it will be observed that, since the pressures increase more rapidly

* See papers by the writer on the efficiencies of engines, as per references already given.

than the temperatures, the range of temperature in the high-pressure cylinder is greatest; while, the same weight of steam passing through the whole series, the low-pressure cylinder presents the largest area of condensing surface in proportion to steam used. These differences are to a certain extent, though not wholly, compensatory. It may be assumed, however, without serious error, that the necessity of applying jackets or other methods of reducing internal wastes, will apply substantially as imperatively to one cylinder as to another, and that the adoption of a common ratio of expansion for both or all cylinders, or of apportioning the ratios with reference to the equal division of power among them, will be found perfectly admissible and will introduce no serious avoidable loss. Authorities have greatly differed in their views as to the relative advantage of jacketing one or another cylinder; but it is at least safe to jacket all, and probably, as above indicated, best to do so. The importance of the jacket evidently becomes less as other expedients for reducing wastes of this kind are adopted and are made more effective; as by increasing speed of engine, by superheating, by reheating between cylinders; and cases may be imagined in which the jackets may cease to have sufficient value to justify the acceptance of the risks and expense incurred in their employment. The same is true of the more complicated forms of valve-gear needed to secure an approximation to the ideal distribution of steam.

The extent to which expansion may be economically carried in a single cylinder will vary somewhat with the initial temperature and pressure, and with the physical condition of the working fluid; but it may be taken as ordinarily not less than two and a half expansions for unjacketed engines with wet steam and three or four for the better class of engines. The total expansion ratio thus becomes, for several types of multi-cylinder engines, as below:

MULTI-CYLINDER ENGINES.

No. cyls.	*1.*	*2.*	*3.*	*4.*
r	2·5 to 3	6·25 to 9	16 to 27	40 to 81
p_1	25 to 30 lbs.	60 to 100 lbs.	120 to 300 lbs.	350 to 800 lbs.

Expansion is here assumed to be approximately hyperbolic, and the terminal pressure to be eight or ten pounds per square inch. General experience to date thus indicates that a triple expansion engine should do best work up to a pressure of about 250 or 300 pounds, and that the four-cylinder engine should be adopted from that point up to the highest pressures likely to be adopted in the steam-engine, the double expansion compound serving its purpose well below the lowest figures above assigned to the triple engine. Any of the four types of engine may be made to overlap the range assigned its labor by suitably providing against wastes occurring within the engine by increased speed, by superheating, by expedients giving higher effectiveness to the jackets, or other methods of improvement. Any system which increases the efficiency of the simple engine will improve the efficiency of the compound, and will correspondingly increase the range of pressure through which it will give satisfactory gain as compared with the former.

(*To be continued.*)

On the Dilatation and Compressibility of Water and the Displacement of its Maximum Density by Pressure.*

By E. H. Amagat.

Translated by Chief Engineer Isherwood, U.S.N.

I have described in a preceding communication (*Comptes Rendus*, August 23, 1886), the method I adopted for the determination of the dilatation and compressibility of liquids under very high pressures, and I gave some of the results obtained, but not corrected for the deformation of the piezometers. The ascertainment of this deformation, which I am now engaged on, appears so long and difficult, that I think I should without delay make known the results I have obtained for water, which has a special interest because of its phenomenon of maximum density.

* *Comptes Rendus*, 1887, p. 1159.

Mr. Tait, who, previously to me, investigated water between wide limits of pressure, has given for that liquid the following formula:

$$\frac{v - v_0}{p\, v_0} = 0{\cdot}0000489 - 0{\cdot}00000025\ T - 0{\cdot}0000000067\ t$$

applicable between 6° and 15°, and between 150 and 500 atmospheres, but I believe that no physicist up to the present time has examined the subject relative to the maximum of density.

The method I employ gives directly the pressure necessary to maintain a constant mass of water at the same volume at all temperatures, consequently, if with two different temperatures the same pressure is obtained, there must lie between them, as regards that pressure, the temperature corresponding to the maximum of density. The use of the same pressure with the different temperatures obviates the necessity of correction for the elasticity of the material of the piezometer, for the calculation of which the data are still wanting. The correction for difference of temperature relative to the dilatation has been made by provisionally admitting that the coefficient of dilatation of glass does not vary with the pressure, a supposition which cannot cause any notable error, inasmuch as in the present case the variation of temperature is only of a few degrees.

As regards pressure, I have carried my experiments on water up to 3,200 atmospheres; and as regards temperature, I have operated between zero and 50°, with the following results:

At 200 atmospheres, in round numbers, the maximum density of water retrograded towards and nearly reached zero. It appeared to be between zero and 0·5° (half a degree).

At 700 atmospheres there was no longer any maximum of density above zero, the form of the curves indicating clearly that it had passed below zero; further, the investigation could be followed to still lower temperatures since the freezing point of water is lowered by increased pressure.

To well understand the *ensemble* of the phenomena and

the resulting consequences, curves should be formed by taking the pressures as abscissas and the volumes as ordinates, to represent at different temperatures the volumes occupied under all the pressures by the same mass of water. These curves intersect each other successively at points which correspond to the change of the sign of dilatation of the water, and fall successively in the order of the temperatures, the pressure increasing. At 200 atmospheres they are in the normal order, becoming more and more closed or straightened as they correspond to lower temperatures. The pressure constantly augmenting, they become more and more opened in such a manner that the co-efficient of dilatation increases rapidly at first, and then more slowly with the pressure, which is just the contrary of what takes place with all the other liquids I have examined. Towards 3,000 atmospheres the co-efficient of dilatation ceases to increase, and under greater pressures it probably diminishes as in the case of other liquids; the effect, too, is much less marked as the temperature, with equal pressure, is higher.

There results, likewise, from this disposition of the curves that, between two different pressures, the difference of the ordinates and consequently the co-efficient of compressibility diminishes when the temperature increases, which is also contrary to what occurs in the case of other liquids, a fact long since shown by Grassi, and a quite natural result of the disappearance of the maximum of density. Furthermore, and for the above reasons, this diminution of the co-efficient of compressibility disappears when the pressure increases, and it also disappears when the temperature increases, conformably to the results of Messrs. Pagliani and Vicentini, according to whom the compressibility of water ceases to decrease above 50°. The temperature at which this inversion takes place decreases when the pressure increases.

Generally, a sufficient increase of pressure or of temperature gives water a tendency to conform to the ordinary case of liquids; and towards 3,000 atmospheres the last traces have disappeared of the perturbations of the general law which result from the existence of maximum density.

Such are the general results of the *ensemble* of the phe-

nomena. I shall continue the study in detail, and investigate the subject below zero. I can give the definitive numerical results only after I have finished the work now in progress on the deformation of the piezometers.

In conclusion, I would add that none of the liquids I have studied up to the present time, has shown a maximum of density under any pressure, which is contrary to a prevision formulated recently by Mr. Grimaldi, based on assumed constancy of the co-efficient of compressibility within wide limits of pressure, an assumption in complete disaccord with the results I have obtained with all the liquids I have investigated.

RESEARCHES ON THE SPHEROIDAL STATE OF WATER.*

By Mr. Gossart.

Translated by Chief Engineer Isherwood, U.S.N.

The results which I have the honor of presenting to the Academy, are relative to the temperature of water in the state of calefaction under decreasing pressures comprised between 760 millimetres and 0·5 millimetre.

Recently, Mr. Luvini (*Il Nuovo Cimento, t. xvii*) has published some researches on the temperature of water, of alcohol, and of ether, calefied in a vacuum, but he could not maintain constant the temperature of the crucible containing the liquid and merely resting on a brick heated under a glass bell. Forming the vacuum rapidly, he followed the simultaneous change of a thermometer placed in the liquid, and of the pressure. From his observations he concluded that *the temperature of the liquid spheroid is the same as the temperature of ebullition under the pressure in the enclosed space* and that there could be thus directly caused the freezing of water, but there cannot be affirmed, particularly as the crucible is not taken out and is still very hot, that the liquid has not ceased to be in the spheroidal state.

* *Comptes Rendus*, 1887, page 1270.

I have sought to verify the relation indicated by Mr. Luvini, but maintaining constant the temperature of the crucible, the volume of the liquid, and the pressure, in order to measure with certainty the data of the experiment.

A copper plate is raised at its centre in the form of a truncated cone, the upper base of which is a concave plate of 0·04 metre diameter and 0·01 metre depth, brazed on. The plate is turned up around the base of the cone so as to form a kind of box in which a current of cold water is circulated. Inside the truncated cone and above the plate is a lighted gas-jet, placed there to heat the upper base which contains the liquid.

Around the plate is a circular gutter or groove in which is cemented by marine glue a glass bell having two tubulures. Through the central tubulure is passed a mercurial thermometer having a flat bulb so that it may be immersed in the liquid or drawn out to remove it from the radiation of the crucible.

The lateral tubulure is traversed by the tube for making the vacuum and by another and narrower tube for conducting the liquid that feeds the drop. With a Carré machine the vacuum is produced at the same time in the glass bell and in the flask containing the supply of liquid.

A large tube of lead traverses the bottom of the plate, and leads the small drops accidentally thrown and the vapor into a large cold balloon containing sulphuric acid. From the neck of the balloon go tubes to a barometric manometer, and to a trumpet with a tubulure for the entrance of air or the introduction of any gas. By sealing with water all the stoppers and joints I have been able to maintain, for over twenty-four hours, a pressure of less than one millimetre.

The following are the results obtained with distilled water for pressures comprised between 760 millimetres and 0·5 millimetre:

(1) Below 33° the temperature of the liquid is higher than the temperature of its ebullition under the pressure in the surrounding space.

(2) From 33° to 50°: the difference between these two temperatures is very feeble, sometimes nothing, and not

surpassing 0·5° at most; it is sometimes positive and sometimes negative.

(3) Above 50° up to 90°—the last temperature I observed—the temperature of the drop is constantly less than the temperature of ebullition under the same pressure. Mr. Boutigny obtained 97° for the temperature of calefied water under the pressure of 760 millimetres.

(4) While for the low temperatures the differences increase regularly enough between 0° and 30°, yet above 50° the differences, though always preserving the same sign, do not appear to vary as regularly. This is a point to which I propose to return.

These conclusions are warranted by the following experimental results:

Pressures in Millimetres.	*Temperature of the Liquid Calefied.*	*Temperature of Ebullition.*	*Differences.*
2	0°	—12°	+ 12°
8	15	8	+ 7
21	24·5	23	+ 1·5
35	32·25	31·8	+ 0·45
48	37·5	37·5	0
83	48	48	0
138	58	58·5	— 0·5
152	60	60·5	— 0·5
241	70	70·8	— 0·8
341	78	79	— 1
567	90	92	— 2

In carrying the rarefaction to the extreme limit of 0·5 millimetre, I have seen a drop of water, of at least two grammes, become, notwithstanding the high temperature of the crucible, first opaque, and then a rounded piece of solid ice, which remained during more than a quarter of an hour rocking gently on the crucible, which was always kept heated by the gas-jet. I thus realized the experiment imagined by Mr. Luvini, but not realizable by the method he employed.

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, November 19, 1889.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, November 19, 1889.

MR. T. C. PALMER, Vice-President, in the Chair.

Members present: Prof. R. L. Chase, Mr. A. T. Eastwick, Mr. Lee K. Frankel, Mr. F. Lynwood Garrison, Mr. Reuben Haines, Prof. L. B. Hall, Dr. H. W. Jayne, Dr. H. H. Keller, Mr. F. C. Lewin, Mr. Otto Lüthy, Mr. W. W. McFarlane, Mr. W. L. Rowland, Prof. S. P. Sadtler, Prof. Edgar F. Smith, Prof. N. Wiley Thomas, Dr. Wm. H. Wahl, Mr. L. E. Williams and two visitors.

The following gentlemen were elected to membership in the Section: Mr. Geo. L. Norris, Pencoyd, Pa.; Mr. Hugh A. Galt, 1011 Spruce Street, Philadelphia; Mr. Lucius E. Williams, Swarthmore College, Swarthmore, Pa.; Mr. Hermann Schanche, Gray's Ferry Chemical Works, Philadelphia.

Dr. Jayne asked for information on By-Law IV regarding the dropping of delinquent members. The question was as to the necessity of action on the part of the Section in such cases. It was decided that no special action of the Section was necessary, but that delinquent members shall, at the proper time, simply be dropped from the list; in accordance with this decision, the Treasurer notified the Secretary to drop the names of two delinquents from the list.

The nomination of officers for the ensuing year was then taken up. The following nominations for President were made: Mr. T. C. Palmer, Prof. S. P. Sadtler, Prof. R. L. Chase. On motion, the nominations for President were closed.

Nominations for two Vice-Presidents were then made. The following gentlemen were put in nomination: Dr. H. H. Keller, Mr. W. L. Rowland and Prof. Henry Trimble. On motion, the nominations for Vice-Presidents were closed.

Dr. W. C. Day was nominated for Secretary, Dr. H. W. Jayne for Treasurer, and Dr. Wm. H. Wahl for Conservator.

Mr. W. W. McFarlane gave a description of some new dyeing materials, in which he explained the use of a number of dyes which have recently been introduced into this country by the representatives of Fried. Bayer & Co., of Elberfeld; samples of dyed products were also exhibited.

Among other interesting matters, the speaker stated that "carmine blue" is dyed with the use of Glauber's salt and sulphuric acid, in the same way as indigo carmine or extract, and further, that the carmine blue will probably displace the indigo extract at no distant period in the future. "Sulphon Azurin" is also used in dyeing cotton, using a boiling bath and some alkaline salt, such as borax, sal-soda, sodium phosphate or silicate. The blue produced is similar in shade to that of indigo, and is said to withstand the action of light and of dilute acids as well.

Benzo-black-blue is dyed in cotton in the same way as other benzo colors, and very dark shades are the result. There are two shades of this color, designated respectively as G and R.

The paper was discussed by Messrs. McFarlane and Palmer. Dr. Wahl, from whom a paper was expected, announced that he must defer, until a later meeting, his paper on "a new gold-like alloy;" and gave in place of this, a statement of further results obtained by him in the electrolytic deposition of platinum, exhibiting specimens of work. As the investigation is not yet entirely completed, and certain details of the mode of procedure are to be made the subject of letters-patent, the speaker preferred, for the present, to withhold the same from publication. Dr. Wahl also made some critical remarks on statements made in a paper by A. J. Rogers, on "Experimental Researches in the Reduction of the difficultly-reducible Metals," which was published in the *Proceedings of the Wisconsin Natural History Society*, April, 1889, expressing doubts, based on theoretical considerations, as to the accuracy of one of the results announced by the author; namely, that he had obtained "a yield of aluminium six times greater than had ever been obtained by electrolysis."

Mr. F. Lynwood Garrison presented some remarks on the Paris Exposition, with special reference to Metallurgy and Fuels. As these remarks will be embodied later on in a full and comprehensive report to the INSTITUTE, they are omitted here; this paper was followed by a general discussion of some of the statements it included.

Prof. E. F. Smith read a paper on the occurrence of vanadium in caustic potash. This paper was referred for publication He then presented another on the subject of nitration by the use of nitrogen trioxide as obtained by the action of nitric acid on arsenic trioxide. This paper was also referred for publication.

Professor Smith next presented the following results of further work in the electrolysis of metallic sulphocyanide solutions. His object in presenting these results was to reserve for the future the field upon which he has entered. In addition to the results already reported in a former paper, it was observed that iron, cobalt and nickel in sulphocyanide solutions were fully deposited by weak currents, and that the presence of a sulphocyanide in manganese solutions prevented the formation of the dioxide, and when the latter had

already precipitated the addition of KCNS would effect its re-solution. To these facts may be added that mercury, cadmium, bismuth and lead deposit from sulphocyanide solutions. With lead, a behavior analogous to that noted with manganese was observed.

Approximate quantitative separations were made in several cases, but the complete development of these observations requires further study. Another line of experiment has been the electrolysis of metallic phosphates in the presence of free phosphoric acid. Mercury, silver, copper, cadmium, lead, iron, zinc, cobalt, and manganese have given interesting results qualitatively, and quantitatively. Separations seem possible when regard is had to the proper condit on of the current. The speaker stated that although in possession of quantitative figures in some of these cases, he preferred to postpone their publication until a careful examination has been made with each metal. Curiously enough, with manganese phosphate dissolved in phosphoric acid there is no separation of dioxide; the solution slowly acquires a red tint, and in time becomes turbid, although the addition of more acid causes the turbidity to disappear.

Dr. Warwick, at the request of Professor Smith, has begun an electrolytic study of the metallic formates; the results obtained will be communicated later.

Adjourned. WM. C. DAY, *Secretary.*

EXPERIMENTAL RESEARCHES IN THE REDUCTION OF THE DIFFICULTLY-REDUCIBLE METALS.

By A. J. Rogers.

[*Reprinted from the Proceedings of the Wisconsin Natural History Society, April, 1889.*]

This pamphlet of eighteen pages gives the result of experiments made by the author, upon the reduction of sodium and of aluminium from their salts, by electrolysis, at a high heat. The experiments are carefully made, giving proportions of raw materials, strength of current, time employed, and practical results as compared with the theoretical. The author gives first a *résumé* of some conclusions arrived at in a paper by him, read before the American Association for Advancement of Science, at Ann Arbor, in 1885, in which among other points established, he finds that from fused sodium chloride, 61 per cent. of the theoretical amount of sodium is reduced by electrolysis; this being the average result of six experiments. It thus seems that with suitable apparatus from 5 to 6 pounds of Na could be produced in 24 hours to one electrical horse-power, thus, if there were no practical difficulties in the construction of crucibles and other apparatus involved, nor in working continuously on a large scale with a raw material so cheap and pure as NaCl, the metal could be obtained at a small cost and could be applied to the reduction of other difficultly-reducible metals, including that very valuable metal Al.

He next turns his attention to the alloys of sodium with lead, and also with tin. He finds that "they can be heated to a higher temperature than pure Na or K, in acid (silicious) crucibles, without the Na or K attacking the crucible."

Description of the properties of the sodium-lead alloys are given: the proportions of the two metals varying from 1 part of sodium with 9 parts of lead, up to 1 part sodium with $1\frac{5}{8}$ parts lead. These richer alloys can be cut with a knife, like sodium, and act very rapidly when thrown upon

water. The same properties are peculiar to the sodium-tin alloys.

These alloys are formed by passing a current through melted NaCl in crucibles containing lead or tin serving as a cathode.

A series of nine experiments are reported, in most of which, however, cryolite was mixed with the salt. A small amount of aluminium was in all cases reduced, which was separate mostly from the lead- or tin-sodium alloy. But the principal yield of Al was obtained by heating the sodium alloy with cryolite afterwards in another crucible. It may be interesting to cite a part of one experiment.

"*Experiment 8.*—Passed 80 ampères with 24 volts through four crucibles in series, for six hours, using 1 part of cryolite to 3 parts of NaCl with 450 grains lead in each crucible. * * * Two hundred and fifty grains of quite pure Al was obtained, with a large amount of Na in the remelting with cryolite. There was then actually obtained, besides all losses, in round numbers, 1 pound of Al to the electrical horse-power per day of 24 hours.

"Probably 8 to 10 per cent. can be obtained from cryolite, where the theoretical yield is 12·85 per cent.

"The best results, and, in fact, the only quantitative results that have yet been published, so far as I am aware, for the separation of Al by electrolysis, are reported by Dr. John Hopkinson, of the Kleiner process, where 3 grains were produced to the electrical horse-power per hour, which would be about one-sixth of a pound in 24 hours."

Mr. Rogers' results may be summed up as follows:

(1) The formation of a rich alloy of lead or tin with sodium, by electrolyzing common salt at a high heat, in presence of lead or tin.

(2) The reduction of aluminium from cryolite, or from the double chloride of aluminium and sodium, by simple heating with the above sodium alloy.

(3) A yield of aluminium, six times greater than has ever been obtained by electrolysis.

His paper is well worth the attention of all metallurgists.

P.

ACTION OF THE GAS FROM As_2O_3 AND HNO_3 UPON *p*-OXYBENZOIC ACID.

By Edgar F. Smith.

[*Read at the Stated Meeting of the Chemical Section, November 19, 1889.*]

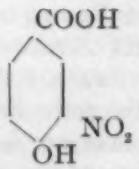
In vol. viii, p. 99, of the *American Chemical Journal*, I called attention to the fact that when methyl salicylate, in ethereal solution, was exposed to the gas arising from arsenic trioxide and nitric acid, ethers of *α* and *β*-meta-nitro-salicylic acids were produced. This procedure gave a ready method for the production, as well as an easy means of separating these two acids, the ether of the *α*-acid being readily soluble, while that of the *β*-acid was practically insoluble in ether.

The ethyl ether of meta-oxybenzoic acid, in ether, gave when acted upon as above ethers of *β*-nitro-meta-oxybenzoic acid (m. p. 230° C.) and trinitro-meta-oxybenzoic acid (m. p. 111° C.). The details of this investigation may be found in the *Proceedings of the American Phil. Soc.*, September 7, 1888. I have recently experimented in the same line wih *p*-oxybenzoic acid. The starting point was ethyl para-oxybenzoate, prepared according to the recommendation of Hartmann in the *Journal für praktische Chemie* [II], **16**, 50. The ether thus obtained, after crystallization from water, gave the constant melting point 112°·5 C., as stated by Graebe (*Annalen*, **139**, 146), and not 116° C., as given by Hartmann. The pure ether was next dissolved in ordinary ether, and the solution then acted upon for one and one-half hours, in the cold, by the vapors from nitric acid and arsenic trioxide. The flask containing the ethereal solution was corked and allowed to stand in a cool place for several days, after which the ether was distilled off. The residue was dark and oily, but after several hours became solid and crystalline. By solution in hot alcohol and recrystallization long, stout, red-colored needles were obtained. These melted regularly at 69°–70° C. Barth (*Journal für prakt. Chemie*,

100, 369), speaking of the action of nitric acid upon ethyl *p*-oxybenzoate mentions two products, ethyl nitroparaoxybenzoate and ethyl dinitroparaoxybenzoate. His description of the mononitro-ether is so meagre that I was not able to determine at first whether I was dealing with a well-known compound or an entirely new product. The subsequent analysis of the free acid left no doubt as to the identity of my compound and that described by Barth. This chemist remarks that the melting point of the nitro-ether lies below —100° C., I have found it as above —69°–70° C. On boiling the ether with caustic potash for some time and then acidulating the alkaline liquid a crystalline mass separates. It dissolves readily in hot water, crystallizing from it, on cooling, in long needles with a faint yellow color. At times the needles showed a flesh-red color; this was removed by boiling the aqueous solution with animal charcoal. When pure the acid melted at 184°–185° C., the same as the acid obtained by Barth. A nitrogen determination, made by Mr. Seal of this laboratory, gave 7·95 per cent. N. The required N for a mononitro-*p*-oxybenzoic acid is 7·65 per cent.

An attempt to estimate the nitrogen in the ether by the Kjeldahl method, failed.

Griess (*Berichte*, **20**, 480) also obtained nitro-*p*-oxybenzoic acid of melting point 185° C., and showed that it was identical with the acid he had previously prepared from *p*-amidonitro-benzoic acid by boiling with KOH, so that its constitution and that of the acid prepared by me as above described is undoubtedly



Hasse (*Berichte*, **10**, 2,188) states that nitro-*p*-oxybenzoic acid contains water of crystallization. The acids of Barth, Griess and myself are anhydrous.

While *p*-nitro-oxybenzoic acid requires a large volume of

hot water for its solution, its sodium salt is very soluble, and from its concentrated liquid separates in beautiful red colored needles forming bundles.

The amide of the acid ($C_6H_3(NO_2)$ OH. $CONH_2$) consists of beautiful orange-yellow colored tufts. It melts at 160°–161°, and dissolves easily in hot alchohol.

The above account concludes my study of the action of the vapors from nitric acid and arsenic-trioxide upon the three hydroxy-benzoic acids. The results briefly summarized are these:

With ortho-oxy-benzoic acid two nitro acids were obtained; with meta-oxy-benzoic acid one nitro acid and a tri-nitro-meta product resulted, and with para-oxy-benzoic acid one meta-nitro acid.

The course of the reaction in these three cases (the *m*-oxy-acid excepted) was not attended by any troublesome intermediate products, and for this reason the method may perhaps become serviceable in the nitration of other oxy-acids.

CHEMICAL LABORATORY OF THE UNIV. OF PA.,
PHILADELPHIA, November 18, 1889.

VANADIUM IN CAUSTIC POTASH.

BY EDGAR F. SMITH.

[*Read at the Stated Meeting of the Chemical Section, November 19, 1889.*]

The occurrence of vanadium in commercial caustic soda has been noticed (See Baumgarten, *Zeitschrift für Chemie*, 1865, **605**, and Donath, *Zeitschrift für Analyt. Chemie*, **21**, 45). As far as I am aware, it has not been observed in caustic potash, hence the following lines.

While engaged in making certain decompositions, for which I employed the ordinary stick potash, I was rather surprised, after saturating the alkaline solutions with hydrogen sulphide, acidulating with hydrochloric acid, and heating for several hours, to discover that the separated sulphur showed a decidedly chocolate-brown color. This occurred

repeatedly. The quantity of dark material was never very great, yet it was present, even in potash from alcohol. Some preliminary experiments were made which pointed to vanadium. I therefore saturated the warm aqueous solution of three pounds of stick potash with hydrogen sulphide. Heat was applied for several hours longer, and during this period the liquid gradually assumed a yellow to deep red color. Hydrochloric acid was added to distinct acid reaction. The separated sulphur was quite dark in color. After filtration and washing, the residue was dried and treated with carbon disulphide to extract the free sulphur. The chocolate-colored mass remaining after this treatment dissolved, with exception of a slight quantity, in yellow ammonium sulphide, from which it was reprecipitated by dilute acid. Again washed, treated with carbon disulphide, and carefully ignited, there remained a crystalline mass. With a small quantity of this last product I made the phosphorous bead test—yellow, passing through dark to green when cool. Another special test consisted in dissolving a portion of the ignited residue in a drop of conc. sulphuric acid, free from iron. One cc. of water was next added, and to this colorless solution from one to three drops of a dilute potassium ferrocyanide solution, whereupon the liquid acquired a fine green coloration. This latter test Dr. Walz (*American Chemist*, vol. vi, p. 453) employed in detecting the minute quantities of vanadium in American magnetites. He considers it conclusive evidence of the presence of vanadium. The most important test, and that which I applied to the remainder of the ignited residue, after effecting its solution in nitric acid, was to add a large piece of ammonium chloride to the ammoniacal solution. The morning following, crystals of ammonium vanadate had separated. These gave the true vanadium bead, and when ignited, moistened with pure, strong nitric acid and evaporated, left the deep red-colored residue characteristic of vanadium compounds.

The vanadium sulphide, as first obtained, was impure, consequently the reactions were at times masked, and it was only after eliminating some silver and iron that the reactions were unquestionable.

The impure sulphide from the three pounds of caustic potash weighed about one-half gramme.

CHEMICAL LABORATORY OF THE UNIV. OF PA.,
PHILADELPHIA, November 18, 1889.

NOTES AND COMMENTS.

CHEMISTRY.

NEW PHOTOGRAPHIC DEVELOPERS.—*Eikonogen*, introduced but a few months ago by Dr. Andresen, of Berlin, as a developing agent for dry plates and bromide paper, seems to have grown into favor with more extended tests and to justify in a high degree the expectations formed. The following are the most prominent facts of its current literature, already quite extensive. Chemically it is the sodium salt of amido-β-naphthol-β-sulphonic acid, having the symbol

$$C_{10}H \begin{cases} SO_3Na \\ OH \\ NH_2 \end{cases}$$

The formulæ for its use, as well as its action, are closely analogous to those of hydroquinone. The deposit formed by it is, however, said to be finer and of a very delicate bluish-black color, thus bringing out all the finest details. By some hydroquinone is regarded as giving stronger negatives, all things being equal, but the eikonogen as giving better half shadows, and consequently better for portraiture than for landscape photography. It is said to be particularly well adapted for lantern slides and line work negatives; and in spectroscopic photography it seems as sensitive as pyrogallol in giving the shades of depth corresponding to variation in brightness of the spectral lines, and at the same time to give a picture with blacker lines, more easily seen under the microscope.

For bromide paper, according to General Brown, it is undoubtedly the developer of the future, affording warmer tones than the oxalate, and beautifully clear whites, without acid flushing, with simple rinsing with water before fixing. Whilst the appearance of the picture is slow, especially as a used developer, preferably twenty-four hours old, is preferred, the development is regular and uniform to every detail, without risk of staining; and the same solution can be used for a number of prints. It is said to be unaffected in its action by variation in temperature, and therefore adapted to all climates. It is non-poisonous; does not stain the fingers; will keep over a month mixed; acts so energetically that only half the exposure is required as that with pyrogallol, and development occupies a much shorter time. The solution can be used over and over again without staining until its reducing power is exhausted. It is, on the other hand, especially adapted to development of over-exposures. With all its excellencies it is a cheap developer, and will keep indefinitely as a dry powder. Its slight solubility, however, will prevent its use in concentrated stock solutions, as pyrogallol.

The commercial article is accompanied by formula for its use, and the recommendation by some to reduce the strength of these does not seem to be approved by the most successful experimenters with it. The following formula, by General Brown, for a normal developer, will serve to indicate the general character of solutions used.

Solution I.—Sodium sulphite, 15 grains; eikonogen, 7½ grains; water, 1 ounce.

Solution II.—Carbonate of potassium, 80 grains; water, 1 ounce.

For use mix with three parts of I, one-half to one part of II, according to exposure.

Pyrocatechine.—Orthodihydroxybenzol, an isomer of hydroquinone, with the formula $C_6H_4(OH)_2$ is at present a subject of careful investigation as a developing agent for dry plates. The results thus far are quite promising. Its use as a photographic developer was suggested as early as 1859 by Wagner. Eder and Toth announced its developing power in alkaline solution in 1880. Professor Benoist, of Tolouse, last year published results of considerable experience with it. Dr. Arnold pronounces it fifteen times as energetic as hydroquinone, and enumerates among its chief excellencies, the excellent tone and good qualities of the negatives produced by it; the absence of fog; loss of sensitiveness to light of the plates after immersion in the developer, so that development may be continued after immersion in ordinary gaslight, or even in diffused daylight without injury; great latitude of exposure as development proceeds slowly, but uniformly; freedom from stain to the hands; simplicity of formulæ for solutions, and possibility, on account of its solubility, of preparing concentrated stock solutions which will keep well if the pyrocatechine is chemically pure, and which can be used by the drop; convenience in carrying the small quantities of ingredients required for development; development without motion; and withal, on account of its high reducing power, the expense, at twenty-five cents per gramme, is not exorbitant, as that quantity will develop 100 to 150 plates 13 x 18 cm. He employs the following stock solutions; *a*, one per cent. solution of pyrocatechine; *b*, twenty per cent. solution of potassium carbonate. Sodium carbonate he does not find to answer as well. For development of a well-exposed plate, 7 x 9 inches, one cc. of *a* and 5 — 10 cc. of *b* are mixed with 60 — 80 cc. of water. Sulphite of soda does not seem necessary or desirable. The mixed developer will not keep, and should be used only once. Carl Irna, employing it with carbonate of soda and sodium sulphite, as in Balagny's formula for hydroquinone, found it more energetic than the latter, whilst others have found it less so. Dr. Eder in his more recent experiments was particular to employ it in its purest form, as was Dr. Arnold, and found it a rapid, energetic developer, yielding coffee-brown negatives of good quality. He employed the following solutions: *A*, pyrocatechine 1 part, sulphite of soda 4 parts, water 40 parts; *B*, carbonate of potash 4 parts, water 40 parts, mixing for use one volume of *A* with two of *B*. The sulphite of soda is not absolutely necessary, but with it the solution will keep clear much longer.

Paraphenylendiamin—$C_6H_4(HN_2)$, has been found by Dr. Eder to act well as a developer for dry plates, having about the same energy as pyrogallol or hydroquinone. As far as experiments have been conducted, the development with it is regular, and negatives produced are delicate and soft. It was used with potash, without sulphite, which retards the development greatly, but prevents the solution from becoming colored. C. F. H.

BOOK NOTICES.

HINTS ON HOUSE BUILDING.—Some desultory notes in popular form, mostly reprinted from *The Mechanical News*, by Robert Grimshaw, author of, etc. Second and enlarged edition. Practical Publishing Company, New York.

This is a small book with a very long title. It makes no pretension to fine writing, but deals in practical suggestions. Directions are given for the proper choosing of sites for building, correct modes of construction, interior arrangements, etc. What is said *inter alia* respecting ventilation, dimensions of rooms, roofs, correct and safe construction of flues and the notes on heating should commend it to the attention of all desiring healthy and convenient homes. The booklet is dedicated "to those who board, and to those who inhabit flats and are able to do better," *i. e.*, to build homes; it is a very good argument throughout that every man should become a house-owner. N.

A TREATISE ON STEAM-BOILERS. By Robert Wilson, C.E. Enlarged and illustrated from the fifth English edition by J. J. Flather, Ph. B. New York. John Wiley & Sons. 1889. pp. 36a, 437.

This well-known book has lost nothing by its treatment in the hands of its American editor. It has for years been the best work on the subject of steam-boilers and only needed the details of American practice to make it invaluable. These details have to a great extent been added in the present edition. It is a matter of regret that the additions were not made in the body of the text, but were added in the shape of an introduction and an appendix. The introduction is to some extent historical, as cuts are given of spherical, haystack and wagon boilers, after which are given many of the more modern forms, but omitting entirely the marine type. Fair examples of the plain cylinder, flue, tubular, Lancashire and Galloway boiler are described, and the various vertical and sectional are shown, the introduction furnishing a fairly satisfactory groundwork on which to begin the study of the design. After the introduction is given the text of the English edition with practically no changes. This part of the work could easily have been made more satisfactory to the American reader by replacing the commercial names used by their equivalents, which are more familiar in this country, and bringing the text to date. The use of corrugated furnaces is spoken of as something simply proposed, instead of having been in use now for a number of years. The use of steel is spoken of as something comparatively rare. As this part of the text is entirely English, it would not have been amiss to have at least

stated the brands of American irons and something of their relative properties. A few errors have been carried along from one English edition to another and appear in this one, the most noteworthy one being for the thickness of a sheet between two series of stays, in which

$$\frac{w\,l}{2} = c\,b\,d^2$$

is given as the strength of a rectangular beam, l, long, b, broad, and d, deep; w being the load uniformly distributed, and c the strength of the material, the beam being fixed at the ends.

The appendix supplements the text very nicely, as it answers many of the questions a beginner would ask. Figures showing many of the details of bracing are given, and many of the boiler attachments, such as safety valves, fusible plugs, gauges, water columns, grate bars and sediment collectors are shown by examples of the most approved forms. The inevitable steam-boiler explosion pictures are shown, including the picture of the explosion of the vertical boiler which first (?) appeared in the *Scientific American* in 1882, and in nearly every book and paper on the subject since. While figures showing the running gear of an agricultural boiler after an explosion, and the trajectory of a boiler which started from a third-story window and landed a few squares away, and apparently illuminated the houses it passed over, may be of considerable interest, they are entirely out of place in a work of this kind.

Numerous tables are given in the appendix, which are of considerable value, among others the values of American coals, standard dimensions of boiler tubes, ratio of heating surface to horse-power and grate, factors of evaporation, and Kent's chimney tables. Taken as a whole, the work is in a more satisfactory shape than in the English edition, but might be even better adapted to the needs of the American reader. H. W. S.

THE GARDEN OF EDEN. The allegorical meaning revealed, etc. One of the numerous lectures delivered by Mrs. Victoria Claflin Woodhull, in the principal cities throughout the United States.

This composition is of the class which takes an idea, more or less important, and proceeds to run away with it and make it a universal key to all that is mysterious in life. Such an idea (with due deference to Mr. Donnelly) was that of making the roughly-printed old folios of Shakspere, with their clumsy typography, contain a cipher of unparalleled intricacy. Such are the interpretations of prophecy worked out of the Scriptures from time to time, and made to indicate either the end of the world, or the identity of some man who has made himself prominent with the antichrist. These amusements are harmless enough, and seem inseparable from the life of even civilized man. They amount simply to ingenious exercises requiring the term of the prophecy they interpret to disprove the solution. This lecture, however, though the same in general scope, is different from the harmless crazes above alluded to, inasmuch as it gives evidence of having been conceived in a brain addicted

to salacious introspection. All the professions of high-toned virtue with which the pamphlet abounds, do not suffice to mitigate its distinctly unclean influence. The interpretation of the meanings of the words Pison, Gihon, Hiddekel and Euphrates, the four branches of the river which went out of the garden of Eden, is somewhat ingenious but very far-fetched indeed. The Garden of Eden is the abdominal cavity, whence the river branches into "Pison," the circulating blood; "Gihon," the stream which carries off the waste solid residues; "Hiddekel," which performs the same function for the liquids, and "Euphrates," which "flows through the reproductive system." This is an excellent pamphlet to omit from the shelves of a library of useful books. F.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, November 20, 1889.*]

HALL OF THE FRANKLIN INSTITUTE,
WEDNESDAY, November 20, 1889.

JOSEPH M. WILSON, President, in the Chair.

Present, fifty-four members and ten visitors.

Additions to membership since the previous meeting, forty-six.

Mr. WM. L. BOSWELL, one of the delegates of the INSTITUTE to the late Universal Exposition in Paris, presented an oral report on the subject of "The Fire Defences of Paris, as Compared with those of American Cities, and especially of Philadelphia." The speaker discussed the theme at some length, and presented an instructive contrast of conditions and usages in vogue in the two countries. The subject was illustrated graphically. It was freely discussed by Messrs. FULLERTON, WEAVER, WIEGAND and BOSWELL. Mr. BOSWELL'S report will appear in the JOURNAL.

The President made some remarks upon his observations of trade schools in France and England, having been charged with the task of investigating the organization and mode of operation of such institutions on behalf of the projected school of Mr. A. J. DREXEL, of this city. The President proposed to make this theme the subject of an elaborate report, for early publication in the JOURNAL.

Mr. W. N. JENNINGS exhibited, with the aid of the lantern, a series of photographic views, taken along the line of the Pennsylvania Railroad, shortly after the disastrous floods of last spring, that proved so destructive of life and property. The pictures embraced views showing the break in the South Fork Dam, the remains of the well-known Conemaugh Viaduct, and of wrecks of a number of locomotives and trains.

The Secretary presented his usual report of technical progress, and the meeting adjourned. WM. H. WAHL, *Secretary.*

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR JUNE, 1889.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, June 30, 1889.

TEMPERATURE.

The mean temperature for the month of June, 1889, was 66°.5, which is from two to three degrees below the average, and two degrees below the corresponding month of last year.

The means of the daily maxima and minima were 76°.4 and 57°.0, respectively.

Neither extreme high nor low temperatures were noted during the month.

The warmest period at most stations was on the 21st, and the coldest on the 2d, 7th and 24th. Frost occurred in some of the northern border counties on these dates.

The highest recorded temperatures were: Reading, 95°; Carlisle, 93°; Pottstown, 91° and York, 91°.

The lowest were Dyberry, 33°; Honesdale, 35°, and State College, 37°.

BAROMETER.

The mean pressure was 0.06 above the normal. The greatest pressure was on the 24th, and the least on the 5th. The extreme range was about 0.75.

PRECIPITATION.

The average rainfall for June, 1889, was 5·43 inches, which is an excess of 1·63 inches.

The entire month was characterized by frequent and heavy rainfalls. The great and destructive rain-storm of the 30th and 31st of May continued to the morning of June 1st over a great extent of country. On the last-named date, over twenty stations report a fall of from one to three inches, making a total in inches for the three days' storm, as follows: Wellsboro, 9·80; McConnellsburg, 8·99; Grampian Hills, 8·60; Harrisburg, 7·78; Selins Grove, 7·53; Charlesville, 7·50; Huntingdon, 6·57; Coudersport, 6·33; Phillipsburg, 6·09; Smethport, 6·00; New Bloomfield, 6·14; Emporium, 5·97; Hollidaysburg, 5·80; Eagles Mere, 5·53; Altoona, 5·33; Girardville, 4·59; Somerset, 4·43; Myerstown, 3·37.

For the month of June, 1 station had rain on 21 days, 4 stations on 20 days, 1 station on 19 days, and 3 stations on 18 days. The average for the state was 15 days.

The following stations report the greatest total in inches: Wellsboro, 10·04; Myerstown, 8·66; Reading, 8·21; Girardville, 8·01; Scisholtzville, 7·91; Ottsville, 7·58; Smith's Corner, 7·54; Uniontown, 7·36; Quakertown, 7·31, and Harrisburg, 7·18.

The excessive rainfall, and the unusual number of rainy days, marks the month as exceptionally wet. With the exception of the 2d, 23d and 24th, rain fell on every day in some part of the state.

WIND AND WEATHER.

The prevailing winds were from the west and southwest, with no severe and general gales. A few frosts were reported, but no damage of any amount resulted from them. The month was excellent for the growth of all vegetation, and large crops were secured where harvesting was not interfered with by the excessive wet.

In some sections the damage to the hay crop was very great.

Average number.—Rainy days, 15; clear days, 5; fair days, 12; cloudy days, 13.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Charlesville, 4th, 11th, 14th, 16th, 21st, 28th; Reading, 4th, 5th, 9th, 11th, 15th, 17th, 21st, 29th, 30th; Hollidaysburg, 14th, 21st; Quakertown, 9th, 11th, 15th, 17th, 21st, 29th; Emporium, 21st, 30th; State College, 4th, 21st, 28th; Phillipsburg, 15th, 21st; West Chester, 5th, 10th, 15th, 17th, 21st; Coatesville, 5th, 10th, 15th, 17th, 21st, 30th; Rimersburg, 14th, 19th, 21st, 27th, 30th; Carlisle, 9th; Harrisburg, 17th; Swarthmore, 5th, 10th, 11th, 14th, 15th, 21st, 30th; Uniontown, 14th; Huntingdon, 4th, 11th, 15th, 17th, 28th; Indiana, 11th; New Castle, 4th, 17th, 27th; Myerstown, 5th, 9th, 11th, 15th, 17th, 21st; Smethport, 21st; Greenville, 17th, 30th; Pottstown, 4th, 15th; New Bloomfield, 4th, 9th, 15th, 21st; Philadelphia, 4th,

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather

County.	Station.	Elevation above Sea Level (feet).	Barometer.			Temperature.												Relative Humidity.	Dew Point.	Precipitation.
							Maximum.		Minimum.				Daily Range.							
			Mean.	Highest.	Lowest.	Mean.	Highest.	Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.	Least.	Date.			Total Inches.
Allegheny,[1]	Pittsburgh,	847	30·004	30·420	29·720	67·3	87·0	21, 30	46·0	2	76·1	60·4	15·7	24·0	7	7·0	1	70·4	56·8	4·93
Bedford,	Charlesville,	1,300	. . .	. . .	. . .	64·8	86·5	21	43·0	24	76·1	58·7	17·4	29·5	24	9·0	11	81·8	59·3	4·26
Berks,[1]	Reading,	304	30·043	30·399	29·721	67·8	95·0	20	44·0	7	80·9	58·9	22·0	34·0	21	3·0	11	85·1	62·6	8·21
Blair,[2]	Altoona,	1,181	. . .	. . .	. . .	69·6	88·0	22	47·5	2	79·2	60·1	19·1	26·5	16	11·0	19	62·5	56·0	4·73
Blair,	Hollidaysburg,	947	. . .	. . .	. . .	66·0	90·0	21	40·0	2	78·0	53·0	25·0	43·0	8	10·0	12	85·0	62·0	2·71
Bradford,	Wysox,	718	30·010	30·466	29·659	69·0	87·5	21	39·0	7	76·7	55·0	21·7	38·0	7	6 1	12	82·2	60 0	4·86
Bucks,	Forks of Neshaminy,	. . .	. . .	. . .	. . .	66·5	82·0	21	54·0	7	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4·49
Bucks,	Quakertown,	536	30·030	30·450	29·570	67·2	87·5	21	40·0	7	79·0	56·1	23·9	35·7	7	14·7	5	86·5	63·7	7·31
Cameron,	Emporium,	1,030	. . .	. . .	. . .	68·2	90·0	21	38·0	7	77·7	53·9	23·8	39·0	21	2·0	5	74·8	60·0	4·63
Centre,	State College—Agricultural Experiment Station,	1,191	29·977	30·385	29·629	64·9	85·0	21	37·0	2	73·9	52·4	21·5	31·0	21	14·0	5	83·2	59·9	5·37
Centre,	Phillipsburg,	1,350	. . .	. . .	. . .	62·4	88·0	29, 30	38·0	2	75·3	53·1	22·2	35·0	24	11·0	5	. . .	. . .	5·84
Chester,	West Chester,	455	30·024	30·446	29·643	68·9	86·3	21	48·0	7	77 5	61·2	16·3	26·0	7	10·0	5	75·0	60·5	5·38
Chester,	Coatesville,	380	. . .	. . .	. . .	68·7	89·5	20, 21, 28	42·0	7	80·1	58·6	21·5	35·0	7	12·0	30	. . .	. . .	5·99
Clarion,	Rimersburg,	1,500	. . .	. . .	. . .	68·2	86·0	20, 30	47·0	1	74·1	61·7	12·4	25·0	21	2·0	5	. . .	. . .	. . .
Clarion,	State Normal School,	1,530	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Clearfield,	Grampian Hills,	1,450	. . .	. . .	. . .	64·5	88·0	21	48·0	1, 2	73·0	60·0	15·0	28·0	24	6 0	5	. . .	. . .	3·71
Clinton,	Lock Haven,	560	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Columbia,	Catawissa,	491	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Crawford,	Meadville—Allegheny College,	1,050	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Cumberland,	Carlisle,	480	. . .	. . .	. . .	69·1	93·0	21	50·0	2	78·5	63·1	15·4	31·0	20	2·0	12	84·4	64·0	4·59
Dauphin,[1]	Harrisburg,	361	30·054	30·480	29·690	67·4	89·0	21	50·0	2	76·8	60·2	16·6	26·0	13	3·0	12	76·6	59·4	7·18
Delaware,	Swarthmore—Swarthmore College,	190	30·016	30·436	29·655	69·3	87·2	20	46·2	5	78·1	59·8	18·3	32·5	8	10·9	10	78·5	63·0	5·48
Erie,[1]	Erie,	681	30·007	30·460	29·680	64·0	82·9	9	45·0	1	70·0	57·0	13·0	22·0	9	4·0	22	76·0	56·0	6·02
Fayette,	Uniontown,	1,000	30·022	30·332	29·740	67·8	87 0	21	44·0	2	76·2	58·1	18·1	30·0	24	6·0	1	79 0	61·5	7·36
Fulton,	McConnellsburg,	875	. . .	. . .	. . .	66·2	87·0	21	40·0	7	77·6	57·2	19·4	36·0	7	5·0	19	78·1	58·2	5·17
Huntingdon,	Huntingdon—The Normal College,	650	. . .	. . .	. . .	65·2	89·0	29	38·0	2	75·1	54·6	20·5	35·0	7	8·0	18	. . .	. . .	5·60
Indiana,	Indiana—State Normal School,	1,350	. . .	. . .	. . .	67·9	87·0	21	44·0	23	76·5	58·2	18·3	29·0	21	10·0	26	80·2	61·0	3·39
Lawrence,	New Castle,	932	. . .	. . .	. . .	68·7	97·0	29	38·0	6	77·1	53·3	23·8	35·0	7	15·0	11	. . .	. . .	6·50
Lebanon,	Myerstown,	474	30·014	30·722	29·654	66·3	87·4	20	43·0	7	78·9	58·4	20·5	34·0	7	11·2	12	90·0	63·8	8·66
Lebanon,	Anville—Lebanon Valley College,	339	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Luzerne,	Drifton—Drifton Hospital,	1,655	. . .	. . .	. . .	63·6	86·0	21	44·0	8	75·9	55·0	20·9	34·0	8	10·0	5	. . .	. . .	4·99
McKean,	Smethport,	1,500	. . .	. . .	. . .	67·4	88·0	30	38·0	25	75·8	52·0	21·8	37·0	25	6·0	11	80·0	61·0	5·93
Mercer,[1]	Greenville—Thiel College,	1,000	29·954	30·390	29·642	63·5	87·0	30	41·5	1	73·7	54·8	18·9	32·0	24	9·9	22	. . .	. . .	3·51
Montgomery,	Pottstown,	150	. . .	. . .	. . .	71·3	91·0	21	53·0	24	78·9	64·0	14·9	28·0	21	3·0	5	76·5	62·0	6·20
Northampton,	Bethlehem,	360	. . .	. . .	. . .	70·2	88·0	21	46·0	7	79·1	60·0	19·1	35·0	8	7·0	25	73·0	61·0	5·28
Perry,	New Bloomfield,	400	. . .	. . .	. . .	66·2	90·0	20	40·0	19	74·2	54·2	20·0	38·0	9	12·0	12	. . .	. . .	6·25
Philadelphia,[1]	Philadelphia,	117	30·050	30·460	29·680	69·8	88·0	20, 21	54·0	6, 7	79·4	63·3	16·1	22·0	20	10·0	12	74·0	60·8	3·39
Potter,	Coudersport,	1,670	. . .	. . .	. . .	65·2	86·0	20, 21	35·0	7	75·4	48·8	26·6	41·0	20	11·0	1	80·4	60·4	4·80
Schuylkill,	Girardville,	1,000	30·052	30·457	29·716	66·0	85·0	21	47·0	7	75·7	56·0	19·7	33·0	8	11·0	12	. . .	. . .	8·01
Snyder,	Selins Grove,	445	. . .	. . .	. . .	68·2	85·0	16, 30	55·0	6, 7	75·7	63·0	12·7	20·0	24	6·0	5	. . .	. . .	5·10
Somerset,	Somerset,	2,250	. . .	. . .	. . .	60·4	83·0	21	41·0	1, 23	73·6	54·4	19·2	30·0	24	7·0	22	. . .	. . .	3·87
Sullivan,	Eagles Mere,	2,000	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Tioga,	Wellsboro,	1,327	29·973	30·463	29·608	63·3	86·0	10, 29	42·0	24	74·2	55·2	19·0	9·5	24	3·0	5	. . .	. . .	10·04
Warren,	Columbus,	1,410	30·121	30·576	29·808	63·2	90·0	30	38·0	6, 7, 24	73·8	52·6	21·2	40·0	24	8·0	11	80·2	55·6	5·12
Wayne,	Dyberry,	1,100	. . .	. . .	. . .	63·0	85·0	30	33·0	7	74·0	52·0	22·0	40·0	7	11·0	12	. . .	. . .	4·24
Wayne,	Honesdale,	1,000	. . .	. . .	. . .	63·7	82·0	10, 29	35·0	7	73·7	53·7	20·0	36·0	7	9·0	1	. . .	. . .	3·13
York,[1]	York,	385	30·036	30·459	29·745	60·5	91·0	21	49·0	1, 2, 24	79·8	59·6	20·2	33·0	7	5·0	25	72·2	59·4	5·13

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

NTARY OBSERVERS OF THE PENNSYLVANIA STATE WEATHER SERVICE FOR JUNE, 1889.

TEMPERATURE.							RELATIVE HUMIDITY.	DEW POINT.	PRECIPITATION.		NUMBER OF DAYS.			WIND.	
		DAILY RANGE.												PREVAILING DI	
MEAN OF MAXIMUM.	MEAN OF MINIMUM.	MEAN.	GREATEST.	DATE.	LEAST.	DATE.			TOTAL INCHES.	NUMBER OF DAYS RAINFALL.	CLEAR.	FAIR.	CLOUDY.	7 A. M.	2 P. M.
76·1	60·4	15·7	24·0	7	7·0	1	70·4	56·8	4·93	18	1	8	21	SW	SW
76·1	58·7	17·4	29·5	24	9·0	11	81·8	59·3	4·16	15	5	12	13	W	SW
80·9	58·9	22·0	34·0	21	5·0	11	85·1	62·6	8·21	16	11	7	12	NW	. . .
79·2	60·1	19·1	26·5	18	11·0	19	62·5	56·0	4·73	17	. . .	. . .	. . .	. . .	. . .
78·0	53·0	25·0	43·0	8	10·0	12	83·0	62·0	2·71	20	5	19	6	SW	W
76·7	55·0	21·7	38·0	7	6 1	12	82·2	60 0	4·86	16	7	7	16	SE	SW
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4·49	11	4	18	8	W	W
79·0	56·1	23·9	35·7	7	14·7	5	86·5	63·7	7·31	17	4	15	11	SW	SW
77·7	53·9	23·8	39·0	21	2·0	5	74·8	60·0	4·63	12	4	16	10	E	W
73·9	52·4	21·5	31·0	21	14·0	5	83·2	59·9	5·37	15	3	13	14	W	W
75·3	53·1	22·2	35·0	24	11·0	5	. . .	. . .	5·84	20	3	9	18	SW	SW
77 5	61·2	16·3	26·0	7	10·0	5	75·0	60·5	5·38	19	11	14	5	S	SW
80·1	58·6	21·5	35·0	7	12·0	30	. . .	. . .	5·99	15	10	12	8	W	S
74·1	61·7	12·4	25·0	21	2·0	5	. . .	. . .	. . .	18	6	11	13	SE	SW
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
75·0	60·0	15·0	28·0	24	6 0	5	. . .	. . .	3·71	17	3	10	17	W	SW
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
78·5	63·1	15·4	31·0	20	2·0	12	84·4	64·0	4·59	17	5	14	11	S	S
76·8	60·2	16·6	26·0	13	3·0	12	76·6	59·4	7·18	20	5	15	10	E	E
78·1	59·8	18·3	32·5	8	10·9	10	78·5	63·c	5·48	10	3	8	19	SW	SW
70·0	57·0	13·0	22·0	9	4·0	22	76·0	56·0	6·02	8	3	9	18	SE	SE
76·2	58·1	18·1	30·0	24	6·0	1	79·0	61·5	7·36	21	7	19	4	W	W
77·6	57·2	19·4	36·0	7	5·0	19	78·1	58·2	5·17	15	8	13	9	W	W
75·1	54·6	20·5	35·0	7	8·0	12	. . .	. . .	5·60	16	5	10	15	W	W
76·5	58·2	18·3	29·0	21	10·0	26	80·2	61·0	3·39	13	4	8	18	SW	W
77·1	53·3	23·8	35·0	7	15·0	11	. . .	. . .	6·50	9	3	4	23	SE	SE
78·9	58·4	20·5	34·0	7	11·2	12	90·0	63·8	8·66	13	7	18	5	W	W
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
75·9	55·0	20·9	34·0	8	10·0	5	. . .	. . .	4·99	11	4	16	10	. .	. .
75·8	52·0	23·8	37·0	25	6·0	11	80·0	61·0	5·93	13	4	14	12	S	S
73·7	54·8	18·9	32·0	24	9·9	22	. . .	. . .	3·51	10	5	5	20	SW	SW
76·9	64·0	14·9	28·0	21	3·0	5	76·5	62·0	6·20	10	13	11	6	W	W
79·1	60·0	19·1	35·0	8	7·0	25	73·0	61·0	5·28	. . .	. . .	. . .	. . .	. . .	. . .
74·2	54·2	20·0	38·0	9	12·0	12	. . .	. . .	6·25	13	5	12	13	S	SE
79·4	63·3	16·1	22·0	20	10·0	12	74·0	60·8	3·39	13	2	13	15	SW	SW
75·4	48·8	26·6	41·0	20	11·0	1	80·4	60·4	4·80	11	7	6	17	W	W
75·7	56·0	19·7	33·0	8	11·0	12	. . .	. . .	8·01	15	10	12	8	W	W
75·7	63·0	12·7	20·0	24	6·0	5	. . .	. . .	5·10	14	3	15	12	SW	SE
73·6	54·4	19·2	30·0	24	7·0	22	. . .	. . .	3·87	14	6	11	13	SW	SW
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
74·2	55·2	19·0	9·5	24	3·0	5	. . .	. . .	10·04	20	4	12	14	S	SW
4 73·8	52·6	21·2	40·0	24	8·0	11	80·2	55·6	5·12	18	4	9	17	SW	SW
74·0	52·0	22·0	40·0	7	11·0	12	. . .	. . .	4·24	11	5	14	11	W	W
73·7	53·7	20·0	36·0	7	9·0	1	. . .	. . .	3·13	12	. . .	. . .	. . .	. . .	. . .
4 79·8	59·6	20·2	33·0	7	5·0	25	72·2	59·4	5·13	13	15	8	7	SW	SW

T. F. TOWNSEND,

Wind.			Observers.
Prevailing Direction.			
7 A. M.	2 P. M.	9 P. M.	
SW	SW	SW	Oscar D. Stewart, Sgt. Sig. Corps.
W	SW	W	Rev. A. Thos. G. Apple.
NW	. . .	SW	C. M. Dechant, C.E.
. . .	. . .	. . .	Dr. Charles B. Dudley.
SW	W	W	Prof. J. A. Stewart.
SE	SW	NW	Charles Beecher.
W	W	W	J. C. Hilsman.
SW	SW	SW	J. L. Heacock.
E	W	W	T. B. Lloyd
W	W	W	Prof. Wm. Frear.
SW	SW	SW	Geo. H. Dunkle.
S	SW	SW	Jesse C. Green, D.D.S.
W	S	W	W. T. Gordon.
SE	SW	S	Rev. W. W. Deatrick, A.M.
. . .	. . .	. . .	C. M. Thomas, B.S.
W	SW	SW	Nathan Moore.
. . .	. . .	. . .	Prof. John A. Robb.
. . .	. . .	. . .	Robert M. Graham.
. . .	. . .	. . .	R. B. Derickson.
S	S	S	J. E. Pague.
E	E	E	Frank Ridgway, Sgt. Sig. Corps.
SW	SW	SW	Prof. Susan J. Cunningham.
SE	SE	SE	Peter Wood, Sgt Sig. Corps.
W	W	W	Wm Hunt.
W	W	W	Thomas F. Sloan.
W	W	W	Prof. W. J. Swigart.
SW	W	SW	Prof. Albert E. Maltby.
SE	SE	SE	Wm. T. Butz.
W	W	W	Wm. H. Kline.
. . .	. . .	. . .	Geo. W. Bowman, A.M., Ph.D.
. . .	. . .	. . .	H. D. Miller, M.D.
S	S	S	Armstrong & Brownell.
SW	SW	SW	Prof S. H. Miller.
W	W	W	Charles Moore, D.D.S.
. . .	. . .	. . .	Lerch & Rice.
S	SE	SE	Frank Mortimer.
SW	SW	SW	Luther M. Dey, Sgt. Sig Corps.
W	W	W	C. L. Peck.
W	W	W	E. C Wagner.
SW	SE	SE	J. M. Boyer,
SW	SW	SW	W. M. Schrock.
. . .	. . .	. . .	E. S. Chase.
S	SW	SW	H. D. Deming.
SW	SW	SW	Wm. Loveland.
W	W	W	Theodore Day.
. . .	. . .	. . .	John Torrey.
SW	SW	SW	Mrs. L. H. Grunewald.

. Townsend, *Sergeant Signal Corps, Assistant.*

| | | |

PRECIPITATION FOR JUNE, 1889.

Erie.	New Castle.	Greenville.	Columbus.	Pittsburgh.	Uniontown.	Clarion.	Indiana.	Smethport.	Somerset.	Grampian Hills	Emporium.	Phillipsburg.	Huntingdon.	Hollidaysburg.	Altoona.	Charlesville.	McConnellsburg.	State College.	York.	New Bloomfield.	Carlisle.	Wellsboro.	Harrisburg.	Selins Grove.	Wynex.	Girardville.	Myerstown.	Drifton.	Reading.	Pottstown.	West Chester.	Coatesville.	Dyberry.	Coudersport.	Honesdale.	Quakertown.	Swarthmore.	Philadelphia.	Scisholtzville.	Frederick.	Ottsville.	Smith's Corner.	Doylestown.	Lansdale.	Forks of Neham'y.	Germantown.	Point Pleasant.	Bethlehem.
.14	1.05	. .	.34	. .	.04	. .	. .	.50	. .	. .	. .	3.26	1.75	.39	2.30	.18	.68	1.94	1.70	2.07	1.50	7.45	3.12	1.07	.14	3.05	1.62	.36	2.01	1.00	1.20	1.07	.71	. .	.25	.95	.58	.46	1.93	.98	.19	1.02	.68	1.67	.70	. .	.44	1.00
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.01	.12	.12	. .	.29	.35	.05	.18	. .	. .	. .	. .	.06	.35	.02	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
.04	. .	. .	. .	.04	.21	. .	. .	.20	.50	. .	. .	.01	.12	.12	. .	.29	.35	.05	.18	. .	. .	. .	. .	.06	.35	.02	. .	. .	. .	. .	.03	.02	. .	. .	. .	.03	. .	. .	.02	. .	.15	.04	. .	. .	. .	.04	. .	. .
.04	1.50	. .	.05	.44	.06	. .	. .	.50	. .	.20	.25	.02	.96	.05	.03	.13	.45	.64	.46	.90	.52	.10	.30	.63	.57	.99	.15	.76	.03	.60	.03	.10	.09	.30	.14	.04	.02	. .	. .	.09	.13	.06	. .	. .	.03	. .	.01	.22
.03	. .	. .	.12	.08	.21	. .	. .	.70	. .	.03	.22	.02	. .	.02	.03	.	. .	.05	.50	. .	.05	.12	.32	.34	.15	.07	.31	. .	.52	. .	.25	.25	.30	.1.	.34	.16	.34	.20	.33	.30	. .	.10	.24	. .	.14	.09	.01	. .
.02	. .	. .	.08	. .	. .	. .	. .	. .	.02	. .	. .	. .	. .	. .	.02	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
.08	.30	. .	.10	. .	.02	. .	.18	.40	. .	. .	. .	. .	. .	.05	. .	. .	. .	. .	. .	. .	. .	.05	. .	. .	.15	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
.30	. .	. .	.97	.10	.43	. .	.01	.30	. .	.30	.60	.45	.15	.01	.03	. .	.17	.22	. .	.14	.20	.05	.08	.08	.05	.20	.06	.09	.11	.04	. .	.03	. .	.32	.10	.32	.04	. .	. .	.48	.05	.05	. .	. .	. .	.01	. .	. .	. .
.24	. .	. .	.12	.06	. .	. .	. .	.40	. .	. .	.16	.08	. .	. .	. .	. .	. .	. .	. .	. .	. .	.05	. .	. .	. .	. .	1.01	. .	.01	. .	. .	.05	. .	.07	.11	. .	. .	.63	. .	.17	.03	.90	. .	.55	. .	.05	.04
.02	. .	. .	. .	.02	.23	. .	.10	.10	.23	.25	.20	.20	.04	.14	.05	.08	. .	.08	. .	.06	.05	.12	.40	.17	. .	. .	.02	. .	. .	. .	.26	.40	. .	.10	. .	. .	. .	. .	. .	. .	. .	. .	. .	.11	. .	. .	. .	. .
. .	.35	.17	.15	.90	.10	. .	.90	.60	. .	.30	.18	.12	.38	.30	. .	.15	.15	.15	.47	.52	.05	.16	.24	.31	.32	.50	.76	.34	.85	.70	.18	.20	.50	.16	. .	.44	. .	. .	.72	.32	.84	.31	.26	.22	.20	. .	1.10	.97
.25	. .	. .	. .	.08	.21	. .	.25	. .	.30	.18	. .	.20	.12	.13	.57	.15	.17	.15	.20	.10	.11	.06	.12	.10	.01	.19	.13	.12	.11	.20	.81	.30	. .	. .	. .	.02	.35	.10	.43	.10	.33	.12	1.02	.99	.34	. .	1.16	.05	.68
. .	. .	. .	. .	. .	.01	. .	. .	. .	. .	. .	. .	. .	.01	. .	. .	. .	. .	. .	. .	. .	.01	. .	. .	. .	. .	. .	. .	. .	. .	.03	. .	. .	. .	. .	.22	.02	.12	. .	. .	.15	. .	. .	. .	. .	.70	. .	. .	. .
.04	. .	.32	.02	.08	.29	. .	.10	. .	.15	. .	. .	. .	.01	.40	. .	1.93	.86	. .	. .	. .	.08	. .	. .	. .	.02	. .	. .	. .	. .	.30	.14	. .	. .	. .	. .	.68	.04	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
.32	.50	.23	.51	1.73	.51	. .	.70	. .	.17	.98	.92	.24	.68	.19	.33	.04	.3	.29	.16	.33	. .	. .	.25	.75	.21	.12	.36	.16	.10	.53	1.17	.61	1.60	.53	.30	. .	1.63	.72	.54	.78	1.72	1.18	.76	.56	.92	. .	.54	.50	.71
.99	. .	.62	.50	.04	.27	. .	.02	. .	.25	.06	. .	.05	.	.02	.12	. .	. .	.19	.05	. .	.03	. .	. .	. .	.80	. .	. .	. .	. .	. .	.09	. .	.37	.30	. .	.41	. .	. .	. .	. .	.77	. .	. .	. .	.16	.04	.25	. .
2.15	.57	1.19	.92	1.14	1.14	. .	. .	.85	.35	.16	1.02	.16	.31	.02	.03	.20	.41	.80	.15	.29	. .	.65	.31	.29	.52	.47	1.67	.48	.99	.10	.32	.39	.41	.80	.61	1.05	. .	.05	.51	. .	.40	.80	.53	. .	. .	.14	.84	.04
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.20	. .	.25	. .	.01	.10	. .	. .	. .	. .	. .	.26	.10	. .	. .	. .	. .	. .	. .	. .	. .	.04	.02	. .	. .	. .	.07	. .	.01	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
.10	. .	.04	.11	.31	.26	. .	.10	.30	.88	. .	.11	.02	.10	.09	.02	.06	.05	.04	. .	. .	. .	.05	.02	. .	.04	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.19	. .	. .	. .	. .
.10	. .	. .	.25	. .	.27	. .	. .	. .	. .	.06	. .	.01	. .	. .	.34	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.01	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
.14	.78	.20	.13	20	.78	. .	.28	.75	.30	. .	.47	. .	.40	.29	. .	.11	26	.97	.0	.81	. .	.42	.18	.30	.95	.27	2.68	.35	. .	.35	.02	.03	.25	2.00	.41	.04	. .	.01	.75	.22	.22	.21	.11	. .	.10	. .	.15	.44
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.45	. .	.35	. .	. .	.44	. .	. .	. .	.80	. .	.73	. .	.10	. .	. .	. .	.01	.10	.65	. .	.11	.45	. .	. .	. .	.14	.13	.06	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	.10	.08	.32	1.25	. .	.40	. .	.30	. .	. .	. .	.05	.06	. .	.15	.13	. .	.01	.08	.05	.10	.04	.10	.41	.21	. .	. .	.03	.85	.03	. .	. .	.20	. .	. .	. .	. .	. .	. .	1.20	. .	. .	. .	. .	. .	. .	. .
.63	. .	.46	.65	.09	.12	. .	.45	.33	.20	.16	.45	.26	.07	.29	.23	.26	.20	.18	.35	.80	.65	.15	.50	.85	.11	1.11	. .	2.06	1.27	1.00	.94	1.11	. .	.71	.50	.76	1.55	2.25	1.35	1.68	1.30	.90	2.04	1.55	2.10	1.37	1.35	1.75	1.78
.04	.65	.18	.02	.21	. .	. .	. .	. .	.03	.26	.05	.01	. .	.01	.04	. .	. .	. .	. .	.01	.02	. .	.06	. .	. .	. .	.21	. .	. .	. .	. .	. .	. .	. .	. .	.01	. .	. .	. .	. .	. .	.01	. .	. .	. .	. .	. .	. .	. .
. .	.80	. .	. .	.02	.67	. .	. .	. .	.09	. .	. .	.05	.45	. .	. .	.50	.43	.12	. .	.14	.13	.08	.12	.62	. .	.09	. .	. .	.05	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	.30	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	.28	. .	. .	. .	. .	.02	. .	. .	. .	. .	. .	.03	.56	. .	. .	. .	.15	. .	.72	. .	. .	.56	.05	. .	.99	. .	. .	. .	. .	. .	. .	.25	. .	. .	. .	. .	1.88	1.15	. .	. .	.53	. .	.17	. .
. .	. .	. .	. .	. .	. .	. .	.10	. .	. .	.10	. .	. .	. .	. .	.02	. .	.06	. .	. .	. .	.05	. .	. .	. .	. .	.06	. .	. .	.12	.23	.06	.11	. .	. .	. .	. .	. .	.04	.22	. .	.15	.04	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
6.02	6.50	3.51	5.12	4.93	7.36	. .	3.39	5.93	3.87	3.71	4.63	5.84	5.60	2.71	4.73	4.26	5.17	5.87	5.13	6.25	4.59	10.40	7.18	5.10	4.86	8.01	8.66	4.99	8.21	6.20	5.38	5.99	4.24	4.80	3.13	7.31	5.48	3.39	7.91	6.41	7.58	7.54	5.82	5.45	4.49	3.36	5.32	5.28

T F. T.

11th, 15th; Coudersport, 21st, 28th; Girardville, 4th, 9th, 28th, 29th; Selins Grove, 4th, 9th, 10th, 15th, 21st, 29th; Somerset, 4th, 16th, 19th; Wellsboro, 15th, 21st, 28th; Columbus, 15th, 16th, 17th, 20th, 21st; Dyberry, 9th, 11th, 15th, 16th, 21st, 29th; York, 11th, 17th, 21st.

Hail.—Dyberry, 15th.

Frost.—Phillipsburg, 24th; Wellsboro, 23d, 24th; Dyberry, 7th; Honesdale, 7th.

Coronæ.—Charlesville, 4th, 11th, 12th; Reading, 15th, 17th; Somerset, 8th, 9th.

Solar Halos.—Charlesville, 21st, 24th, 29th; Reading, 4th, 15th; Pottstown, 4th; Wellsboro, 19th; Dyberry, 3d, 19th, 25th.

Lunar Halos.—Charlesville, 10th; Rimersburg, 9th; Carlisle, 9th, 10th; Indiana, 8th; Wellsboro, 20th.

Auroras.—Greenville, 20th; Girardville, 23d; Selins Grove, 23d.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for June, 1889:

Weather, 76 per cent.
Temperature, 88 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
Chester Oil Company,	Chester.
C. W. Burkhart,	Shoemakerville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Werner & Son,	Emporium.
C. E. Lenhart,	Latrobe.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
S. W. Morrison,	Oxford.
Capt. A. Goldsmith,	Quakertown.
J. L. Morrison,	Sharon.
Wm. A. Engel,	Shenandoah.

Displayman.	*Station.*
Wm. Schrock,	Somerset.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
E. H. Baker,	Williamsport.
New Era,	Lancaster.
State Normal School,	Clarion.
Clarion Collegiate Institute,	Rimersburg.
E. S. Chase,	Eagles Mere.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
Armstrong & Brownell,	Smethport.
J. E. Forsythe,	Butler.
James H. Fones,	Tionesta.
Wister, Hacker & Savage,	Germantown.
W. J. Thompson & Co.,	Clifton Heights.
Steward M. Dreher,	Stroudsburg.
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
Hartford P. Brown,	Rochester.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
Smith Curtis,	Beaver.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. J. Edelman,	Pottstown.
A. M. Wildman,	Langhorn.
N. E. Graham,	East Brady.
B. F. Gilmore,	Chambersburg.
Frank M. Morrow,	Altoona.
A. Simon's Sons,	Lock Haven.
E. W. McArthurs,	Meadville.
J. K. M. McGovern,	Lock No. 4.
Raftsman's Journal,	Clearfield.
W. S. Ravenscroft,	Hyndman.
R. C. Schmidt & Co.,	Belle Vernon.

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR JULY, 1889.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, July 31, 1889.

TEMPERATURE.

The mean temperature for July, 1889, was 71°·2, which is about one degree below the normal, and two degrees above the corresponding month of last year. The greatest departures were in the eastern border counties. The mean of the maximum temperatures was 81°·3; and the mean of the minimum 61° 8. The highest temperatures reported were Charlesville, 96°; Hollidaysburg, 95°; Greenville, 95°; Phillipsburg, 94°; Coatesville, 94°; Grampian Hills, 94°; Bethlehem, 94°; New Bloomfield, 94°, and Philadelphia, 94°. These occurred on the 9th and 10th. The lowest temperatures were Coudersport, 39°; New Bloomfield, 40°; Wellsboro, 42°; Columbus, 42°, and Dyberry, 42°.

July is the warmest month of the year, being two degrees warmer than August, and four or five degrees warmer than June. The mean of the three summer months is two degrees less than July.

ISOTHERMAL LINES FOR JULY.

Lines representing places having the same normal temperature are very difficult to trace over the mountain ranges and deep valleys of Pennsylvania. Observations are usually taken at towns in the river valleys, and such deep depressions have a temperature two degrees higher than that of the country back of them. In preparing the accompanying chart an allowance of about one degree was made for such excess. This will explain the lines passing through the northern counties, particularly at places where somewhat higher summer mean temperatures are recorded. In the broader valley of the Susquehanna, the lines may properly be carried sharply along the valley itself.

ATMOSPHERIC PRESSURE.

The barometer averaged slightly above the normal. The highest pressure occurred on the 6th and 7th, and the lowest on the 19th, 20th, and 23d.

PRECIPITATION.

The rainfall for July averaged 6·80 inches for the state, which is an excess of from two to three inches.

The month was very humid and tropical in character. Rains were frequent and varied from light to torrential over areas little distant from each other. In many places heavy downpours occurred, which were disastrous, and entirely local in character. On the 30th and 31st very heavy rains occurred over the eastern part of the state, which caused heavy floods. The Schuylkill was reported the highest since the flood of 1869. Its banks were overflowed, and it is estimated that at one time ten feet of water were over Fairmount dam. The largest totals in inches for the month were: Landsdale, 15·02; Ottsville, 13·19; Coatesville, 12·93; Frederick, 12·69; Pottstown, 12·50; West Chester, 12·49; Smith's Corner, 12·30; Point Pleasant, 12·30. The smallest were Greenville, 1·04; Erie, 1·68, and Columbus, 2·00. The excess of rainfall extended into New Jersey, Eastern New York, and Connecticut; also, Delaware and Maryland.

WIND AND WEATHER.

The prevailing wind was from the west; no severe gales occurred. In some sections large portions of the hay crop were badly damaged during the harvest season by unfavorable weather. Some wheat was injured, and harvesting was generally delayed by frequent rains. The season has been favorable for the growth of all vegetation.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Charlesville, 3d, 10th, 13th, 19th; Reading, 9th, 10th, 13th, 30th; Hollidaysburg, 2d, 13th, 19th, 29th; Forks of Neshaminy, 11th; Quakertown, 1st, 2d, 10th, 13th, 15th, 29th, 30th, 31st; Emporium, 3d, 9th,

13th, 14th, 30th; State College, 1st, 2d, 3d, 13th, 14th, 30th; West Chester, 4th, 9th, 10th, 11th, 13th, 15th, 29th, 30th; Coatesville, 1st, 4th, 10th, 11th, 13th, 15th, 29th, 30th, 31st; Rimersburg, 1st, 3d, 10th, 12th, 13th, 19th, 23d; Swarthmore, 11th, 13th, 15th; Uniontown, 1st, 2d, 3d, 11th, 13th, 19th; Huntingdon, 1st, 14th, 27th, 29th, 30th; Drifton, 10th; Pottstown, 1st; New Bloomfield, 1st, 2d, 3d, 11th, 14th, 29th; Philadelphia, 1st, 11th, 15th; Coudersport, 1st, 10th; Girardville, 2d, 3d, 10th, 29th, 30th; Selins Grove, 2d, 3d, 10th, 11th, 19th, 29th, 30th; Somerset, 11th, 29th; Eagles Mere, 10th; Wellsboro, 1st, 10th, 13th, 30th; Dyberry, 13th, 29th, 30th; Honesdale, 2d, 3d, 10th, 13th, 31st; York, 10th, 13th, 29th, 30th.

Coronæ.—Reading, 28th.; Wellsboro, 26th, 31st; Dyberry, 7th.

Solar Halos.—Charlesville, 17th; Eagles Mere, 13th.

Auroras.—Quakertown, 15th; Eagles Mere, 28th.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for July, 1889:

Weather, 81 per cent.

Temperature, 91 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
Chester Oil Company,	Chester.
C. W. Burkhart,	Shoemakerville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Werner & Son,	Emporium.
C. E. Lenhart,	Latrobe.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
S. W. Morrison,	Oxford.
Capt. A. Goldsmith,	Quakertown.
J. L. Morrison,	Sharon.
Wm. A. Engel,	Shenandoah.
Wm. Schrock,	Somerset.
Postmaster,	Meadville.

Displayman.	*Station.*
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
E. H. Baker,	Williamsport.
New Era,	Lancaster.
State Normal School,	Clarion.
Clarion Collegiate Institute,	Rimersburg.
E. S. Chase,	Eagles Mere.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
Armstrong & Brownell,	Smethport.
J. E. Forsythe,	Butler.
James H. Fones,	Tionesta.
Wister, Hacker & Savage,	Germantown.
W. J. Thompson & Co.,	Clifton Heights.
Steward M. Dreher,	Stroudsburg.
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
Hartford P. Brown,	Rochester.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
Smith Curtis,	Beaver.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. J. Edelman,	Pottstown.
A. M. Wildman,	Langhorn.
N. E. Graham,	East Brady.
B. F. Gilmore,	Chambersburg.
Frank M. Morrow,	Altoona.
A. Simon's Sons,	Lock Haven.
E. W. McArthurs,	Meadville.
J. K. M. McGovern,	Lock No. 4.
Raftsman's Journal,	Clearfield.
W. S. Ravenscroft,	Hyndman.
R. C. Schmidt & Co.,	Belle Vernon.
Jesse R. Brown,	Lehmasters.
H. W. Mullen,	Centre Valley.

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weath

County.	Station.	Elevation above Sea Level (feet).	Barometer.			Temperature.													Relative Humidity.	Dew Point.
							Maximum.		Minimum.				Daily Range.							
			Mean.	Highest.	Lowest.	Mean.	Highest.	Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.	Least.	Date.			
Allegheny,[1]	Pittsburgh,	847	29·906	30·245	29·678	74·6	93·3	10	55·5	16	83·8	65·2	18·6	27·5	17	10·7	23		67·2	61·2
Bedford,	Charlesville,	1,300	. . .	. . .	. . .	70·4	96·0	12	48·0	26	81·3	62·1	19·2	32·0	17	5·0	26		81·6	64·1
Berks,[1]	Reading,	304	29·997	30·236	29·723	71·8	92·0	9	50·0	16	81·8	63·5	19·3	31·0	6	3·0	4		88·7	68·0
Blair,[2]	Altoona,	1,181	. . .	. . .	. . .	74·5	93·0	10, 11	55·0	16, 25	84·4	64·7	19·7	31·0	15	11·0	2		60·9	60·0
Blair,	Hollidaysburg,	947	. . .	. . .	. . .	71·6	95·0	10	47·0	16	84·5	59·4	25·1	38·0	17	13·0	31		86·0	68·0
Bradford,	Wysox,	718	29·979	30·277	29·696	69·2	91·2	10	44·3	25	80·7	58·9	21·8	34·1	7	8·0	2		83·2	64·0
Bucks,	Forks of Neshaminy,		. . .	. . .	. . .	73·2	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .		. . .	. . .
Bucks,	Quakertown,	536	29·990	30·220	29·680	70·2	91·7	9	52·7	6	84·1	61·0	23·1	30·7	9	7·0	2		90·3	68·2
Cameron,	Emporium,	1,030	. . .	. . .	. . .	70·0	93·0	10	41·0	25	83·2	56·9	26·3	39·0	25	12·0	2		73·6	61·0
Centre,	State College—Agricultural Experiment Station,	1,191	29·914	30·223	29·405	70·3	89·0	10	57·0	15	80·0	63·3	16·7	30·0	25	9·0	3		75·2	62·4
Centre,	Phillipsburg,	1,350	. . .	. . .	. . .	68·0	94·0	10	48·0	16	84·7	53·0	31·7	38·0	12	12·0	1, 3		. . .	. . .
Chester,	West Chester,	455	29·982	30·235	29·667	72·6	90·0	9	55·0	16	80·4	65·6	14·8	22·0	16	4·0	2		79·0	56·5
Chester,	Coatesville,	380	. . .	. . .	. . .	72·9	94·0	9	52·0	16	82·9	63·9	19·0	30·0	7	8·0	27		. . .	. . .
Clarion,	Rimersburg,	1,500	. . .	. . .	. . .	75·0	92·0	10	56·0	25	80·0	70·0	10·0	30·0	25	3·0	18		. . .	. . .
Clarion,	Clarion—State Normal School,	1,530	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .		. . .	. . .
Clearfield,	Grampian Hills,	1,450	. . .	. . .	. . .	70·8	94·0	9	52·0	26	80·7	64·4	16·3	26·0	13	8·0	3, 25		. . .	. . .
Clinton,	Lock Haven,	560	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .		. . .	. . .
Columbia,	Catawissa,	491	. . .	. . .	. . .	70·8	91·0	9	52·0	16	. . .	. . .	. . .	. . .	. . .	. . .	. . .		. . .	. . .
Crawford,	Meadville—Allegheny College,	1,050	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .		. . .	. . .
Cumberland,	Carlisle,	480	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .		. . .	. . .
Dauphin,[1]	Harrisburg,	361	29·998	30·276	29·706	73·8	92·0	9	57·0	16	81·8	65·8	16·0	26·0	17	7·0	19		77·8	65·5
Delaware,	Swarthmore—Swarthmore College,	190	29·973	30·210	29·721	73·0	91·1	9	55·8	16	81·8	65·9	15·9	28·2	8	5·3	19		82·0	67·0
Erie,[1]	Erie,	681	29·980	30·280	29·670	70·0	87·0	9	54·0	15	78·0	63·0	15·0	25·0	22	7·0	20		74·0	62·0
Fayette,	Uniontown,	1,000	29·980	30·162	29·724	74·0	89·0	3, 10, 14	52·0	30	80·1	62·4	19·7	28·0	7	11·0	26		76·2	. . .
Fulton,	McConnellsburg,	875	. . .	. . .	. . .	72·0	92·0	9, 10	48·0	16	84·7	60·8	23·9	40·0	16	8·0	2		78·9	63·7
Huntingdon,	Huntingdon—The Normal College,	650	. . .	. . .	. . .	70·3	90·0	8, 9	48·0	16	81·5	60·2	21·3	33·0	8	14·0	30		. . .	. . .
Indiana,	Indiana—State Normal School,	1,350	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .		. . .	. . .
Lawrence,	New Castle,	932	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .		. . .	. . .
Lebanon,	Myerstown,	474	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .		. . .	. . .
Lebanon,	Anville—Lebanon Valley College,	339	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .		. . .	. . .
Luzerne,	Drifton—Drifton Hospital,	1,655	. . .	. . .	. . .	67·1	88·0	9	50·0	16	77·3	60·4	16·9	27·0	11, 25	7·0	27		. . .	. . .
McKean,	Smethport,	1,500	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .		. . .	. . .
Mercer,[1]	Greenville—Thiel College,	1,000	29·917	30·158	29·580	68·8	95·0	9	44·6	25	82·8	56·4	26·4	43·0	8	10·2	15		87·9	64·9
Montgomery,	Pottstown,	150	. . .	. . .	. . .	74·4	92·0	9	56·0	16	82·0	67·6	14·4	25·0	16	2·0	2		81·0	75·0
Northampton,	Bethlehem,	360	. . .	. . .	. . .	74·0	94·0	9	54·0	15	83·0	63·0	20·0	32·0	9	5·0	2		78·0	66·0
Perry,	New Bloomfield,	400	. . .	. . .	. . .	72·7	94·0	9, 10	40·0	25	81·2	59·1	22·1	46·0	25	9·0	31		. . .	. . .
Philadelphia,[1]	Philadelphia,	117	30·020	30·259	29·669	73·8	94·0	9	60·0	16	83·1	67·5	15·6	24·0	6	5·0	2		76·3	65·3
Potter,	Coudersport,	1,670	. . .	. . .	. . .	67·2	89·0	10	39·0	25	80·6	53·8	26·8	39·0	7	13·0	30		79·0	62·5
Schuylkill,	Girardville,	1,000	29·993	30·214	29·573	72·6	90·0	10	53·0	6	81·0	62·9	18·1	29·0	18	8·0	2		. . .	. . .
Snyder,	Selins Grove,	445	. . .	. . .	. . .	74·4	89·9	9	57·0	25	79·9	68·2	11·7	46·0	28	33·0	25		75·2	68·0
Somerset,	Somerset,	2,250	. . .	. . .	. . .	68·5	89·0	11	45·0	16	79·1	57·9	21·2	35·0	6	9·0	30		83·1	62·2
Sullivan,	Eagles Mere,	2,060	30·019	30·230	29·964	67·5	86·0	10	51·0	16	73·8	62·1	11·7	22·0	6	4·0	19		83·2	61·3
Tioga,	Wellsboro,	1,327	29·942	30·275	29·642	70·3	90·0	10	42·0	25	80·3	61·1	19·2	34·0	25	14·0	19		73·6	52·3
Warren,	Columbus,	1,410	30·081	30·372	29·843	68·1	88·0	10	42·0	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .		78·2	61·0
Wayne,	Dyberry,	1,100	. . .	. . .	. . .	66·6	89·0	10	42·0	25	77·3	52·9	24·4	34·6	18	7·0	31		. . .	. . .
Wayne,	Honesdale,	1,000	. . .	. . .	. . .	66·4	86·0	10	44·0	23	75·8	57·0	18·8	30·0	28	6·0	20		. . .	. . .
York,[1]	York,	385	29·956	30·223	29·702	74·5	95·0	10	52·5	16	83·7	64·8	18·9	29·0	7	6·5	19		72·7	66·3

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

EPORTS BY VOLUNTARY OBSERVERS OF THE PENNSYLVANIA STATE WEATHER SERV

Temperature.												Relative Humidity.	Dew Point.	Precipitatio	
MUM.	Minimum.		Mean of Maximum.	Mean of Minimum.	Daily Range.										
Date.	Lowest.	Date.			Mean.	Greatest.	Date.	Least.	Date.					Total Inches.	Number of Days Rainfall.
10	55·3	16	83·8	63·2	18·6	27·5	17	10·7	23			67·2	61·2	5·48	13
12	48·0	16	81·3	62·1	19·2	32·0	17	5·0	26			81·6	64·1	4·19	14
9	50·0	16	82·8	63·5	19·3	31·0	6	3·0	4			88·7	68·0	9·30	16
10, 11	55·0	16, 25	84·4	64·7	19·7	31·0	15	11·0	2			6·.7	60·0	4·60	12
10	47·0	16	84·5	59·4	25·1	38·0	17	13·0	31			86·0	68·0	6·20	13
10	44·3	25	80·7	58·9	21·8	34·1	7	8·0	2			83·2	64·0	5·17	15
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .			. . .	. . .	10·36	14
9	32·7	6	84·1	61·0	23·1	30·7	9	7·0	2			90·3	68·2	11·54	16
10	41·0	23	83·2	56·9	26·3	39·0	25	12·0	2			73·6	61·0	7·93	10
10	57·0	15	80·0	63·3	16·7	30·0	25	9·0	3			75·2	62·4	4·68	13
10	48·0	16	84·7	53·0	31·7	38·0	12	12·0	1, 3			. . .	. . .	5·21	12
9	55·0	16	80·4	65·6	14·8	22·0	16	4·0	2			79·0	56·5	12·49	. .
9	52·0	16	82·9	63·9	19·0	30·0	7	8·0	27			. . .	. . .	12·93	16
10	56·0	25	80·0	70·0	10·0	30·0	25	3·0	18			. . .	. . .	. . .	7
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .			. . .	. . .	. . .	. .
9	52·0	26	80·7	64·4	16·3	26·0	13	8·0	3, 25			. . .	. . .	7·33	15
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .			. . .	. . .	. . .	. .
9	52·0	16	. . .	. . .	. . .	. . .	. . .	. . .	. . .			. . .	. . .	0·62	12
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .			. . .	. . .	. . .	. .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .			. . .	. . .	. . .	. .
9	57·0	16	81·8	63·8	16·0	26·0	17	7·0	19			77·8	65·5	8·48	18
9	55·8	16	81·8	65·9	15·9	28·2	8	5·3	19			82·0	67·0	8·74	13
9	54·0	15	78·0	63·0	15·0	25·0	22	7·0	20			74·0	62·0	1·68	10
3, 10, 14	52·0	30	82·1	62·4	19·7	28·0	7	11·0	26			76·2	. . .	4·81	12
9, 10	48·0	10	84·7	60·8	23·9	40·0	16	8·0	2			78·9	63·7	8·23	14
8, 9	48·0	16	81·5	60·2	21·3	33·0	8	14·0	30			. . .	. . .	3·38	19
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .			. . .	. . .	. . .	. .
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9	50·0	16	77·3	60·4	16·9	27·0	11, 25	7·0	27			. . .	. . .	9·55	15
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .			. . .	. . .	. . .	. .
9	44·6	25	82·8	56·4	26·4	43·0	8	10·2	15			87·9	64·9	1·04	7
9	56·0	16	82·0	67·6	14·4	25·0	16	2·0	2			81·0	75·0	12·50	14
9	54·0	15	83·0	63·0	20·0	32·0	9	5·0	2			78·0	66·0	9·93	12
9, 10	40·0	25	81·2	59·1	22·1	46·0	25	9·0	31			. . .	. . .	6·08	14
9	60·0	16	83·1	67·5	15·6	24·0	6	5·0	2			76·3	65·3	8·89	17
10	39·0	25	80·6	53·8	26·8	39·0	7	13·0	30			79·0	60·5	7·00	7
10	53·0	6	81·0	62·9	18·1	29·0	18	8·0	2			. . .	. . .	5·46	14
9	57·0	25	75·9	68·2	11·7	46·0	28	33·0	25			75·2	68·0	4·29	9
11	45·0	16	79·1	57·9	21·2	35·0	6	9·0	30			83·1	69·2	5·06	7
10	51·0	16	73·8	62·1	11·7	22·0	6	4·0	19			83·2	61·3	6·30	16
10	42·0	25	80·3	61·1	19·2	34·0	25	14·0	19			73·6	52·3	3·06	12
10	42·0	25	. . .	. . .	. . .	. . .	. . .	. . .	. . .			78·2	61·0	8·00	8
10	42·0	25	77·3	52·9	24·4	34·6	18	7·0	31			. . .	. . .	6·53	12
10	44·0	25	75·8	57·0	18·8	30·0	18	6·0	20			. . .	. . .	5·55	. .
10	52·5	16	83·7	64·8	18·9	29·0	7	6·5	19			72·7	66·3	4·34	8

THER SERVICE FOR JULY, 1889.

PRECIPITATION.		NUMBER OF DAYS.			WIND.			OBSERVERS.
					PREVAILING DIRECTION.			
Total Inches.	Number of Days Rainfall.	Clear.	Fair.	Cloudy.	7 A. M.	2 P. M.	9 P. M.	
5·48	13	6	10	15	N	N	N	Oscar D. Stewart, Sgt. Sig. Corps
4·19	14	10	13	8	W	W	SE	Rev. A. Thos. G. Apple.
9·30	16	12	10	9	NW	NW	NW	C. M. Dechant, C.E.
4·60	12	. . .	. . .	. . .	. . .	. . .	. . .	Dr. Charles B. Dudley.
6·22	13	15	10	6	W	W	S	Prof. J. A. Stewart.
5·17	15	7	12	12	SE	SE	SE	Charles Beecher.
10·36	14	14	7	10	W	W	W	J. C. Hilsman.
11·54	16	11	9	11	N	NW	SW	J. L. Heacock.
7·03	10	15	10	6	W	NW	NW	T. B. Lloyd
4·68	13	12	12	7	W	W	W	Prof. Wm. Frear.
5·21	12	9	10	12	SW	SW	SW	Geo. H. Dunkle.
11·49	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Jesse C. Green, D.D.S.
12·93	16	13	6	12	W	W	W	W. T. Gordon.
. . .	7	12	13	6	W	W	E	Rev. W. W. Deatrick, A.M.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	C. M. Thomas, B.S.
7·33	15	13	10	8	W	SW	W	Nathan Moore.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Prof. John A. Robb.
6·62	12	. . .	. . .	. . .	. . .	. . .	. . .	Robert M. Graham.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	R. B. Derickson.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	J. E. Pague.
8·68	18	7	14	10	E	E	E	Frank Ridgway, Sgt. Sig. Corps
8·74	13	11	10	10	NW	NW	W	Prof. Susan J. Cunningham.
1·68	10	15	9	7	SW	SW	SW	Peter Wood, Sgt Sig. Corps.
4·81	12	14	14	3	SW	SW	SW	Wm Hunt.
8·23	14	12	16	3	S	S	S	Thomas F. Sloan.
5·38	19	7	8	16	W	W	W	Prof. W. J. Swigart.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Prof. Albert E Maltby.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Wm. T. Butz.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Wm. H. Kline.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Geo. W. Bowman, A.M., Ph.D
9·55	15	10	11	10	. . .	. . .	. . .	H. D. Miller, M.D.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Armstrong & Brownell.
1·04	7	11	10	10	SE	. . .	W	Prof S. H. Miller.
12·50	14	15	6	10	W	W	W	Charles Moore, D.D.S.
9·93	12	17	7	7	W	W	W	Lerch & Rice.
6·08	14	10	10	11	W	W	W	Frank Mortimer.
8·29	17	6	9	16	NW	NW	NW	Luther M. Dey, Sgt. Sig Corp
7·00	7	21	6	4	NW	NW	NW	C. L. Peck.
9·46	14	10	4	17	W	W	W	E. C. Wagner.
4·29	9	16	6	9	SE	SE	SE	J. M. Boyer,
5·06	7	15	4	12	NW	NW	NW	W. M. Schrock.
6·30	16	8	11	12	NW	NW	NW	E. S. Chase.
3·06	12	11	8	12	N	N	S	H. D. Deming.
2·00	8	11	15	5	SW	SW	SW	Wm. Loveland.
6·53	12	13	8	10	NW	NW	NW	Theodore Day.
5·55	. . .	. . .	. . .	. . .	. . .	. . .	. . .	John Torrey.
4·34	8	13	10	8	NW	NW	NW	Mrs. L. H. Grenewald.

T. F. TOWNSEND, *Sergeant Signal Corps, Assistant.*

80	42 42 . . . 42 42 . . . 42 80 . . . 80 42 42 . . .	Erie.
.	. . . . .	New Castle.

PRECIPITATION FOR JULY, 1889.

Erie.	New Castle.	Greenville.	Columbus.	Pittsburgh.	Uniontown.	Clarion.	Indiana.	Smethport.	Somerset.	Grampian Hills	Emporium.	Blue Knob.	Phillipsburg.	Huntingdon.	Hollidaysburg.	Altoona.	Charlesville.	McConnellsburg.	State College.	York.	New Bloomfield.	Carlisle.	Wellsboro.	Nisbet.	Harrisburg.	Selins Grove.	Eagles Mere.	Wysox.	Catawissa.	Girardville.	Drifton.	Reading.	Pottstown.	West Chester.	Coatesville.	Dyberry.
. .	. .	. .	. .	. .	.03	. .	. .	. .	. .	1.48	.30	.30	.93	.31	.49	.12	.53	.80	.53	.66	1.30	. .	.19	.69	.54	.27	.65	1.17	1.16	2.00	1.35	. .	2.80	.46	.47	. .
.55	. .	.06	. .	.04	.02	. .	. .	. .	. .	.05	.19	.20	.20	.02	2.83	.23	.66	.71	.03	1.01	.68	. .	.10	.30	.62	.31	.69	.01	.04	1.31	.50	.76	.70	1.68	1.07	.75
.23	. .	.47	.68	.18	. .	. .	. .	. .	. .	.98	.11	.40	.45	.32	.29	1.20	.36	1.04	.35	.02	.30	. .	.08	. .	.14	.72	.32	.20	.57	.29	.38	.02	.07	.25	.16	.37
. .	. .	.08	.15	.29	.80	. .	. .	. .	1.00	.16	1.30	. .	.13	.25	.19	.15	.33	.25	.10	.03	.54	. .	.46	. .	.58	.10	.22	.03	.07	.33	.25	.77	.32	.65	1.02	.45
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PRECIPITATION FOR JULY, 1889.

York.	New Bloomfield.	Carlisle.	Wellsboro.	Nisbet.	Harrisburg.	Selins Grove.	Eagles Mere.	Wyeox.	Catawissa.	Girardville.	Drifton.	Reading.	Pottstown.	West Chester.	Coatesville.	Dyberry.	Quakertown.	Honesdale.	Quakertown.
.66	1.30	. .	.19	.60	.54	.27	.65	1.17	1.16	2.00	1.35	. .	2.20	.46	.47	. .	. .	.48	
1.01	.68	. .	.10	.30	.62	.31	.69	.02	.04	1.31	.50	.76	.70	1.68	1.07	.75	.89	.30	
.02	.30	. .	.02	. .	.14	.72	.31	.20	.57	.29	.38	.02	.07	.25	.16	.37	2.10	.12	
.03	.54	. .	.46	. .	.58	.10	.22	.03	.07	.33	.25	.77	.32	.65	1.02	.45	. .	.48	
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .

Dyberry.	Conderport.	Honesdale.	Quakertown.	Swarthmore.	Philadelphia.	Scicholtzville.	Frederick.	Ottsville.	Smith's Corner.	Doylestown.	Landsdale.	Forks of Neshan'y.	Germantown.	Point Pleasant.	Bethlehem.
. .	. .	'48	'90	'21	'13	. . .	. . .	'57	. . .	. . .	. . .	'01	. .	. . .	'72
'75	'89	'30	'54	'52	'51	. . .	. . .	'87	. . .	. . .	. . .	. . .	. . .	. . .	'98
'37	2'10	'12	'45	'06	'21	2'22	2'20	'03	. . .	1'15	. . .	1'42	1'93	. . .	'04
'45	. .	'48	'54	'63	'61	'80	'40	'70	2'29	'63	2'63	'44	'71	1'90	'80
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
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. .	. .	. .	. .	. .	. .	. .	. .	'01	. .	. .	. .	. .	. .	. .	. .
. .	'94	. .	'11	. .	'04	'57	. .	'58	. .	'42	. .	. .	. .	. .	1'60
'61	. .	'09	'56	'30	'71	'73	1'44	'15	'74	. . .	1'15	'83	1'14	'70	'04
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
'17	'50	'12	'63	'30	'23	'47	'53	'24	'30	'04	1'00	'29	'28	'24	'27
. .	. .	. .	. .	. .	. .	. .	. .	1'52	. .	. .	. .	. .	. .	. .	. .
'46	'93	1'50	2'14	1'58	'48	1'62	2'48	'04	'45	1'99	1'94	2'26	1.00	1'40	1'04
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	'05	. .	'01	. .	. .	. .	. .	. .	'43	. .	'18	. .	. .
. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
'26	. .	'29	'48	. .	'33	. .	. .	2'79	'06	3'18	3'50	. .	. .	'01	'55
'07	. .	. .	'19	1'00	'43	1'39	'34	. . .	4'36	. . .	. .	'84	1'21	3'95	. .
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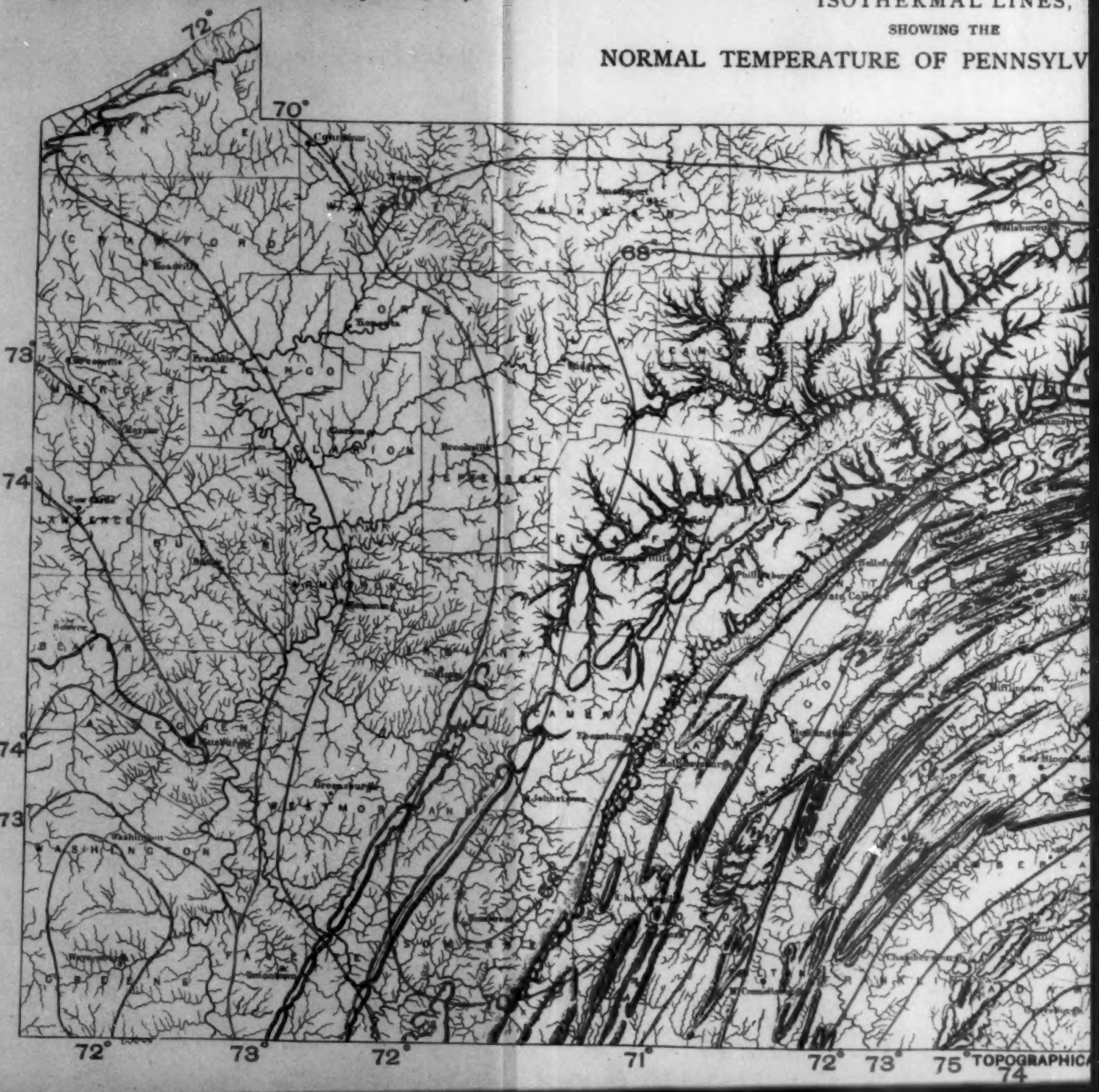
. .	. .	. .	. .	. .	'26	. .	. .	'73	. .	'74	. .	. .	. .	. .	'63
'56	1'99	'51	'64	'57	'88	'70	'47	'03	'78	. . .	. .	'75	'61	. . .	. .
. .	. .	'02	'21	'53	'15	'20	'22	'08	. . .	'40	'45	'05	. . .	'88	. .
'06	. .	'91	'18	'05	'16	. . .	. . .	'24	. . .	. . .	'57	. . .	. . .	'01	'54
'66	1'80	'65	1'72	'31	1'15	. . .	'21	2'60	'13	1'55	. . .	. . .	. . .	2'49	. .
'21		'08	2'20	2'68	2'00	3'06	4'60	2'01	3'17	1'77	3'35	4'09	3'44	'70	2'70
'53	7 90	5'55	11'54	8'74	8'89	11'76	12'69	13'19	12'30	11'87	15'02	10'36	10'30	12'30	9'93

T. F. T.

ISOTHERMAL LINES,

SHOWING THE

NORMAL TEMPERATURE OF PENNSYLV

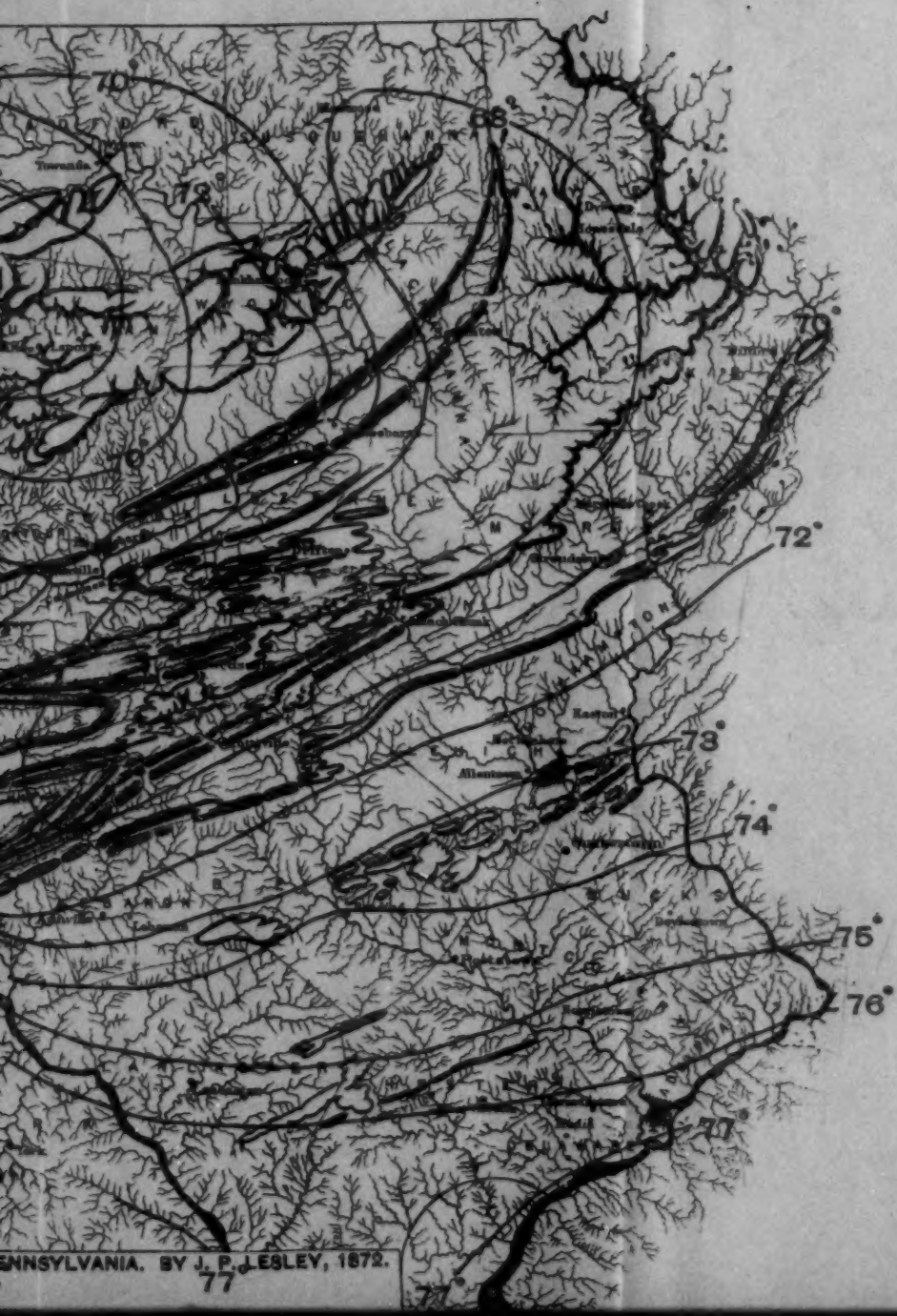


ISOTHERMAL LINES,

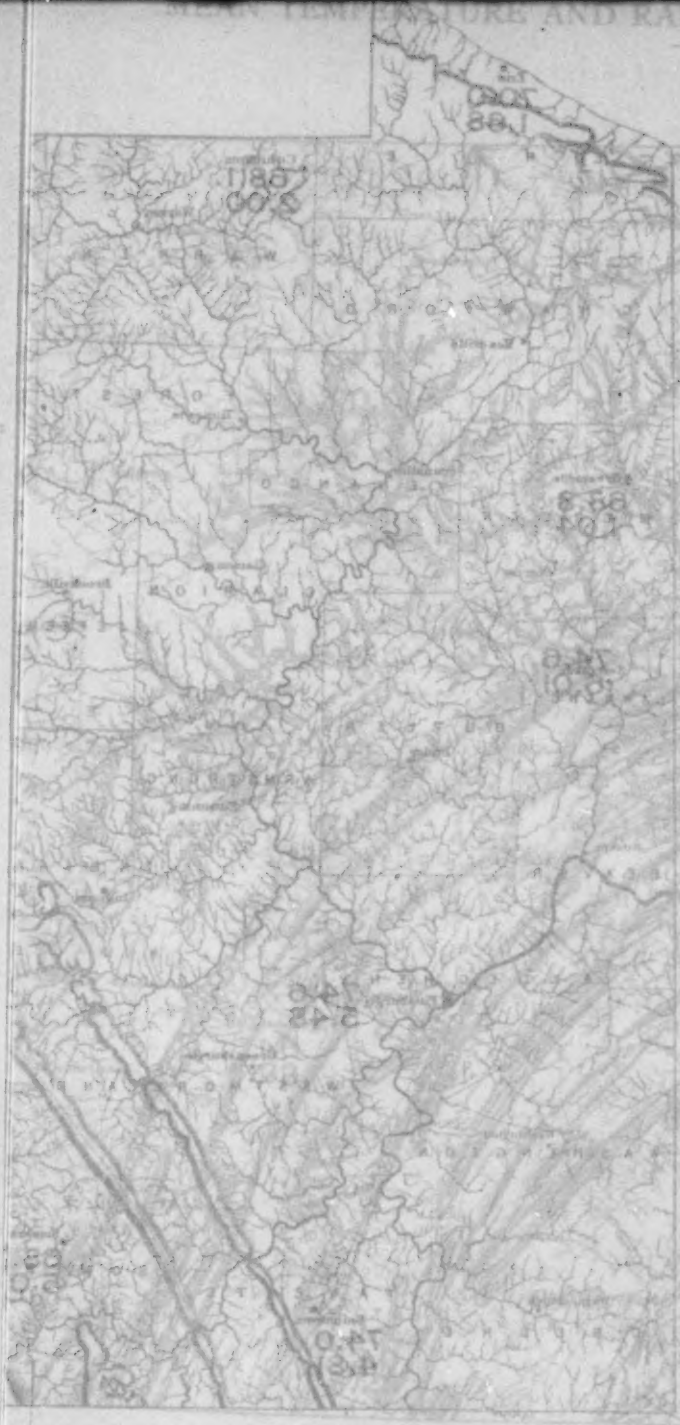
SHOWING THE

NORMAL TEMPERATURE OF PENNSYLVANIA FOR JUL

FOR JULY.



ENNSYLVANIA. BY J. P. LESLEY, 1872.



PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR AUGUST, 1889.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,

PHILADELPHIA, August 31, 1889.

TEMPERATURE.

The mean temperature of the State for the month of August, 1889, was 67°.4, which is two degrees below the corresponding month of 1888, and about three degrees below the normal. The greatest departures were in the agricultural districts of the Lehigh, Cumberland and Lebanon Valleys. The following reports show the highest temperatures recorded during the month: Tionesta, 100°; Carlisle, 95°; Girardville, 95°. The lowest were Columbus, 37°; Wellsboro, 38°; Greenville, 38°.7; and Honesdale, 39°.

At most stations the warmest days of the month were the 21st and 31st, and the coldest the 12th. Stations with the highest monthly mean temperatures were Carlisle, 72°.9; Philadelphia, 72°.8; Pottstown, 72°.0; and Selins Grove, 71°.8. The lowest monthly mean temperatures were Dyberry, 61°.2; Honesdale, 62°.0; and Phillipsburg, 62°.0.

ATMOSPHERIC PRESSURE.

The mean barometer for August was 30.09, which is about .09 above the normal. The highest occurred on the 27th, and the lowest on the 14th. This

low pressure was accompanied by severe thunder-storms, and the heaviest rainfall of the month.

PRECIPITATION.

The average rainfall for the State during the month of August was 3·24 inches. Considered as a whole, this is about normal, but the distribution was very uneven, and some parts of the State suffered from drouth. The following are the greatest monthly totals in inches: Philadelphia, 7·07; Catawissa, 6·17; Girardville, 6·03; Pottstown, 5·05; West Chester, 4·43; Reading, 4·46. The least were Wellsboro, 0·83; Charlesville, 1·06; Hollidaysburg, 1·37; Altoona, 1·52, and Pittsburgh, 1·88. With but few exceptions, very little rain fell after the middle of the month. Up to this time showers were frequent.

WIND AND WEATHER.

The prevailing winds were from the west; no severe wind-storms occurred. The weather was generally favorable for agricultural pursuits and the growth of all staple crops, with the exception of potatoes. These have suffered from rot. The corn crop will be large.

Average Number.—Rainy days, 8; clear days, 15; fair days, 10; cloudy days, 6.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Charlesville, 1st; Reading, 3d, 14th; Hollidaysburg, 4th; Quakertown, 1st, 2d, 3d, 6th, 13th, 14th; State College, 14th; Phillipsburg, 7th; West Chester, 3d, 5th, 6th, 9th, 13th, 14th; Coatesville, 1st, 3d, 5th, 6th, 9th, 23d; Rimersburg, 15th; Emporium, 14th, 21st; Carlisle, 5th; Swarthmore, 3d, 5th, 7th, 14th; Uniontown, 3d, 4th, 5th, 14th; Huntingdon, 14th, 15th; New Castle, 4th, 21st; Myerstown, 5th; Greenville, 2d, 3d; Pottstown, 3d, 14th; Bethlehem, 2d, 3d, 14th; Philadelphia, 1st, 3d, 9th, 14th, 23d; New Bloomfield, 1st, 4th, 14th; Girardville, 1st, 14th; Selins Grove, 1st, 2d, 3d, 13th; Somerset, 2d, 3d, 4th; Eagles Mere, 20th; Wellsboro, 13th, 21st; Columbus, 1st, 14th; Dyberry, 3d, 6th, 13th, 14th, 21st; Petersburg, 14th; Johnstown, 4th; Le Roy, 1st, 14th, 21st; Blue Knob, 3d, 4th, 10th, 13th.

Frost.—Grampian Hills, 12th; Somerset, 12th, 13th; Wellsboro, 12th, 30th; Dyeberry, 29th; Blue Knob, 11th.

Coronæ.—Greenville, 8th; Dyberry, 4th, 8th.

Solar Halos.—Charlesville, 19th, 23d; Le Roy, 23d.

Lunar Halos.—Hollidaysburg, 6th, 9th, 10th.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for August, 1889:

Weather, 84 per cent.

Temperature, 90 per cent.

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Se

County.	Station.	Elevation above Sea Level (feet).	Barometer.			Temperature.													Relative Humidity.	Dew Point.	Precipi
							Maximum.		Minimum.				Daily Range.								
			Mean.	Highest.	Lowest.	Mean.	Highest.	Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.	Least.	Date.				Total Inches.
Allegheny,[1]	Pittsburgh,	847	30·076	30·276	29·711	70·2	89·0	31	50·0	12	80·3	60·0	20·3	30·0	31	7·0	9	68·2	57·6	1·88
Bedford,	Charlesville,	1,300	. . .	. . .	. . .	64·9	87·0	31	42·0	12	78·8	53·8	25·0	42·0	31	14·5	14	80·9	58·3	1·06
Berks,[1]	Reading,	304	30·088	30·302	29·821	67·3	87·0	21	46·0	30	31·1	57·2	23·9	40·0	30	12·5	15	90·6	64·3	4·46
Blair,[2]	Altoona,	1,181	. . .	. . .	. . .	70·4	88·0	3, 22	52·0	28	80·4	60·4	20·0	26·0	13	11·5	9	. . .	. . .	1·52
Blair,	Blue Knob,	2,100	. . .	. . .	. . .	67·7	86·0	31	50·0	15	75·2	60·3	14·9	26·0	30	9·0	9	. . .	. . .	2·40
Blair,	Hollidaysburg,	947	. . .	. . .	. . .	66·7	90·0	31	41·0	12	81·5	52·6	28·9	41·0	31	18·0	9	84·7	62·6	1·37
Bradford,	Wysox,	718	30·089	30·281	29·878	64·4	86·2	21	39·0	29	78·4	52·7	25·7	44·0	30	13·6	20	83·2	58 9	2·07
Bradford,	Le Roy,	875	. . .	. . .	. . .	66·6	83·0	21	48·0	12, 16	75·4	57·0	18·4	26·0	30	7·0	9	. . .	. . .	2·08
Bucks,	Forks of Neshaminy,	. . .	. . .	. . .	. . .	70·1	84·0	21	59·0	30	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5·30
Bucks,	Quakertown,	536	30·080	30·290	29·750	67·7	87·2	21	45·0	30	80·5	57·6	22·9	38·7	30	14·5	15	83·8	62·5	4·76
Cambria,	Johnstown,	1,184	. . .	. . .	. . .	65·9	86·0	31	45·5	12, 13	78·4	54·5	23·9	34·0	31	14·0	10	78·0	59·0	3·95
Cameron,	Emporium,	1,030	. . .	. . .	. . .	69·2	86·0	30, 31	41·0	29	79·3	52·9	26·4	41·0	30	14·0	15	. . .	. . .	3·23
Centre,	State College—Agricultural Experiment Station,	1,191	30·007	30·305	29·645	66·5	85·0	30	46·0	12, 17	77·1	54·9	22·2	37·0	30	14·0	15	74·6	57·0	3·15
Centre,	Phillipsburg,	1,350	. . .	. . .	. . .	62·0	88·0	30, 31	38·0	29	82·0	47·0	35·0	43·0	30	10·0	1	. . .	. . .	2·40
Chester,	West Chester,	455	30·075	30·286	29·753	69·9	86·5	21	53·0	28	70·5	62·0	8·5	27·0	30	6·0	27	77·0	52·0	4·43
Chester,	Coatesville,	380	. . .	. . .	. . .	68·9	89·0	21, 31	46·0	30	81·9	58·7	23·2	41·0	30	11·0	1	. . .	. . .	3·05
Clarion,	Rimersburg,	1,300	. . .	. . .	. . .	67·7	86·0	8	52·0	12, 29	76·5	60·3	16·2	28·0	29	6·0	16	. . .	. . .	. . .
Clarion,	Clarion—State Normal School,	1,530	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Clearfield,	Grampian Hills,	1,450	. . .	. . .	. . .	65·6	86·0	31	40·0	12	76·7	57·0	19·7	36·0	31	10·0	15	. . .	. . .	4·00
Clinton,	Lock Haven,	560	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Columbia,	Catawissa,	491	. . .	. . .	. . .	67·0	83·5	21	49·0	21, 30	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	6·17
Crawford,	Meadville—Allegheny College,	1,050	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Cumberland,	Carlisle,	480	. . .	. . .	. . .	72·9	95·0	30	51·5	12	85·4	63·2	22·2	33·0	30	1·5	23	71·2	65·1	2·49
Dauphin,[1]	Harrisburg,	361	30·106	30·337	29·715	68·6	85·0	21, 31	53·0	28	78·9	60·7	18·2	28·0	30	5·0	23	78·3	61·2	3·58
Delaware,	Swarthmore—Swarthmore College,	190	30·063	30·240	29·770	70·1	87·4	21	54·0	15, 16	79·9	61·9	18·0	29·4	30	8·2	26	79·0	63·0	3·52
Erie,[1]	Erie,	681	30·080	30·280	29·740	67·0	81·0	19	52·0	12	75·0	60·0	15·0	23·0	7	7·0	9	88·0	57·0	2·26
Fayette,	Uniontown,	1,000	30·061	30·185	29·831	69·1	87·0	21	46·0	12	79·2	57·9	21·3	30·0	31	11·0	14	79·5	61·0	3·86
Forrest,	Tionesta,	1,057	. .	. . .	. . .	62·6	100·0	22	45·0	12	80·6	56·3	24·3	45·0	22	6·0	21	. . .	. . .	2·40
Fulton,	McConnellsburg,	875	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Huntingdon,	Huntingdon—The Normal College,	650	. . .	. . .	. . .	67·6	90·0	31	43·0	12	81·4	53·8	27·6	39·0	27	15·0	2	. . .	. . .	1·80
Huntingdon,	Petersburg,	700	. . .	. . .	. . .	68·6	96·0	31	42·0	13	79·6	54·6	25·0	44·0	31	2·0	23	. . .	. . .	3·12
Indiana,	Indiana—State Normal School,	1,390	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Lawrence,	New Castle,	932	. . .	. . .	. . .	69·9	91·0	31	42·0	29	80·6	51·3	29·3	46·0	31	14·0	5	. . .	. . .	2·28
Lebanon,	Myerstown,	474	30·067	30·265	29·781	68·7	89·1	31	47·1	30	81·2	57·4	23·8	39·2	30	11·0	23	83·2	62·5	3·07
Lebanon,	Annville—Lebanon Valley College,	339	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Luzerne,	Drifton—Drifton Hospital,	1,685	. . .	. . .	. . .	64·1	84·0	14	44·0	29	77·8	55·8	22·0	35·0	30	6·0	10	. . .	. . .	4·77
McKean,	Smethport,	1,500	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Mercer,[1]	Greenville—Thiel College,	1,000	30·043	30·307	29·684	63·6	83·9	26	38·7	12	78·8	53·4	25·4	41·0	29	7·1	9	87·4	56·9	1·83
Montgomery,	Pottstown,	150	. . .	. . .	. . .	72·0	88·0	21	50·0	30	81·4	61·5	19·3	36·0	30	12·0	15	80·0	64·5	5·05
Northampton,	Bethlehem,	360	. . .	. . .	. . .	71·1	86·0	21, 31	46·0	30	80·1	59·2	20·9	38·0	30	12·0	3	73·0	62·0	4·10
Perry,	New Bloomfield,	490	. . .	. . .	. . .	67·2	90·0	31	40·0	7	81·2	53·8	27·4	40·0	31	11·0	23	. . .	. . .	2·75
Philadelphia,[1]	Philadelphia,	117	30·096	30·310	29·760	72·8	88·0	22	57·0	28	80·9	64·7	16·2	26·0	30	9·0	26	72·6	61·0	7·97
Potter,	Coudersport,	1,670	. . .	. . .	. . .	65·6	85·0	30	38·0	29	76·3	49·6	26·7	44·0	29	12·0	14	82·2	59 2	3·80
Schuylkill,	Girardville,	1,000	30·105	30·285	29·775	67·9	95·0	2	48·0	12, 28	78·0	56·4	21·6	37·0	2	13·0	3	. . .	. . .	6·03
Snyder,	Selins Grove,	445	. . .	. . .	. . .	71·8	87·0	21	52·0	12, 30	78·4	62·8	15·6	61·0	26	50·0	16	76·7	61·7	6·00
Somerset,	Somerset,	2,250	. . .	. . .	. . .	62·7	83·0	29	41·0	13	75·2	52·1	23·1	43·0	29	10·0	2	87·0	59·2	3·35
Sullivan,	Eagles Mere,	2,000	30·109	30·337	29·900	64·8	79·0	30	48·0	12, 29	72·2	55·7	16·5	26·0	29	5·0	14	77·2	57·2	2·82
Tioga,	Wellsboro,	1,327	30·055	30·317	29·652	62·3	86·0	21	38·0	30	73·6	51·8	21·8	38·2	30	6·0	14	68·2	56·4	·83
Warren,	Columbus,	1,410	. .	. . .	. . .	63·8	92·5	30	37·0	12	78·7	48·8	29·9	52·0	30	7 0	9	79·2	54·4	2·37
Washington,	Canonsburg,	950	. . .	. . .	. . .	67·9	84·0	21, 26	45·0	16	78·1	57·7	20·4	. . .	. . .	. . .	. . .	73·2	58·5	1·64
Wayne,	Dyberry,	1,100	. . .	. . .	. . .	61·2	84·0	30	36·0	29	75·5	49·2	26·3	46·0	30	9·0	5	. . .	. . .	2·85
Wayne,	Honesdale,	1,000	. . .	. . .	. . .	62·0	80·0	2, 21	39·0	30	72·3	50·8	21·5	36·0	30	4·0	15	. . .	. . .	2·60
York,[1]	York,	385	30·074	30·277	29·798	70·2	88·0	31	45·5	18	81·3	58·9	22·4	34·5	18	7·5	7	76·6	62·0	2·83

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

TEMPERATURE.												PRECIPITATIO	
IMUM.	MINIMUM.				DAILY RANGE.								
Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.	Least.	Date.	Relative Humidity.	Dew Point.	Total Inches.	Number of Days Rainfall.
31	50·0	12	80·3	60·0	20·3	30·0	31	7·0	9	68·2	57·6	1·88	6
31	42·0	12	78·8	53·8	25·0	42·0	31	14·5	14	80·9	58·3	1·06	7
21	46·0	30	81·1	57·2	23·9	40·0	30	12·5	15	90·6	64·3	4·46	8
3, 22	52·0	28	80·4	60·4	20·0	26·0	13	11·3	9	. . .	. . .	1·52	7
31	50·0	15	75·2	60·3	14·9	26·0	30	9·0	9	. . .	. . .	2·40	9
31	41·0	12	81·5	52·6	28·9	41·0	31	18·0	9	84·7	69·6	1·37	9
21	39·0	29	78·4	52·7	25·7	44·0	30	13·6	20	83·2	58 9	2·07	8
21	48·0	12, 16	75·4	57·0	18·4	26·0	30	7·0	9	. . .	. . .	2·08	7
21	59·0	30	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5·30	8
21	45·0	30	80·5	57·6	22·9	38·7	30	14·5	15	83·8	62·5	4·76	10
31	45·5	12, 13	78·4	54·5	23·9	34·0	31	14·0	10	78·0	59·0	3·95	8
30, 31	41·0	29	79·3	52·9	26·4	41·0	30	14·0	15	. . .	. . .	3·23	6
30	46·0	12, 17	77·1	54·9	22·2	37·0	30	14·0	15	74·6	57·0	3·15	7
30, 31	38·0	29	82·0	47·0	35·0	43·0	30	10·0	1	. . .	. . .	2·40	8
21	53·0	28	70·5	62·0	8·5	27·0	30	6·0	27	77·0	59·0	4·43	11
21, 31	46·0	30	81·9	58·7	23·2	41·0	30	11·0	1	. . .	. . .	3·05	10
8	52·0	12, 29	76·5	60·3	16·2	28·0	29	6·0	16	. . .	. . .	. . .	4
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
31	40·0	12	76·7	57·0	19·7	36·0	31	10·0	15	. . .	. . .	4·00	13
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
21	49·0	21, 30	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	6·17	. . .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
30	51·5	12	85·4	63·2	22·2	33·0	30	1·5	23	71·2	65·1	2·49	7
21, 31	53·0	28	78·9	60·7	18·2	28·0	30	5·0	23	78·3	61·2	3·58	10
21	54·0	15, 16	79·9	61·9	18·0	29·4	30	8·2	26	79·0	63·0	3·52	8
19	52·0	12	75·0	60·0	15·0	23·0	7	7·0	9	88·0	57·0	2·26	6
21	46·0	12	79·2	57·9	21·3	30·0	31	11·0	14	79·5	61·0	3·86	7
22	45·0	12	80·6	56·3	24·3	45·0	22	6·0	21	. . .	. . .	2·40	4
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
31	43·0	12	81·4	53·8	27·6	39·0	27	15·0	2	. . .	. . .	1·80	5
31	42·0	13	79·6	54·6	25·0	44·0	31	2·0	23	. . .	. . .	3·12	8
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
31	42·0	29	80·6	51·3	29·3	46·0	31	14·0	5	. . .	. . .	2·28	8
31	47·1	30	81·2	57·4	23·8	39·2	30	11·0	23	83·2	62·5	3·07	6
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
14	44·0	29	77·8	55·8	22·0	35·0	30	6·0	10	. . .	. . .	4·77	8
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
26	38·7	12	78·8	53·4	25·4	41·0	29	7·1	9	87·4	56·9	1·83	7
21	30·0	30	81·4	61·5	19·9	36·0	30	12·0	15	80·0	64·5	5·05	7
21, 31	46·0	30	80·1	59·2	20·9	38·0	30	12·0	3	73·0	62·0	4·10	9
31	40·0	7	81·2	53·8	27·4	40·0	31	11·0	23	. . .	. . .	2·75	8
22	57·0	28	80·9	64·7	16·2	26·0	30	9·0	26	72·6	61·0	7·07	12
30	38·0	29	76·3	49·6	26·7	44·0	29	12·0	14	82·2	59 2	3·80	6
2	48·0	12, 28	78·0	56·4	21·6	37·0	2	13·0	3	. . .	. . .	6·03	10
21	52·0	12, 30	78·4	62·8	15·6	61·0	26	50·0	16	76·7	61·7	6·00	6
29	41·0	13	75·2	52·1	23·1	43·0	29	10·0	2	87·0	59·2	3·35	6
30	48·0	12, 29	72·2	55·7	16·5	26·0	29	5·0	14	77·2	57·2	2·82	7
21	38·0	30	73·6	51·8	21·8	38·2	30	6·0	14	68·2	50·4	·83	8
30	37·0	12	78·7	48·8	29·9	52·0	30	7 0	9	79·2	54·4	2·37	11
1, 26	45·0	16	78·1	57·7	20·4	. . .	. . .	. . .	. . .	73·2	58·5	1·64	8
30	36·0	29	75·5	49·2	26·3	46·0	30	9·0	5	. . .	. . .	2·85	7
2, 21	39·0	30	72·3	50·8	21·5	36·0	30	4·0	15	. . .	. . .	2·60	. . .
31	45·5	18	81·3	58·9	22·4	34·5	18	7·5	7	76·6	69·0	2·83	8

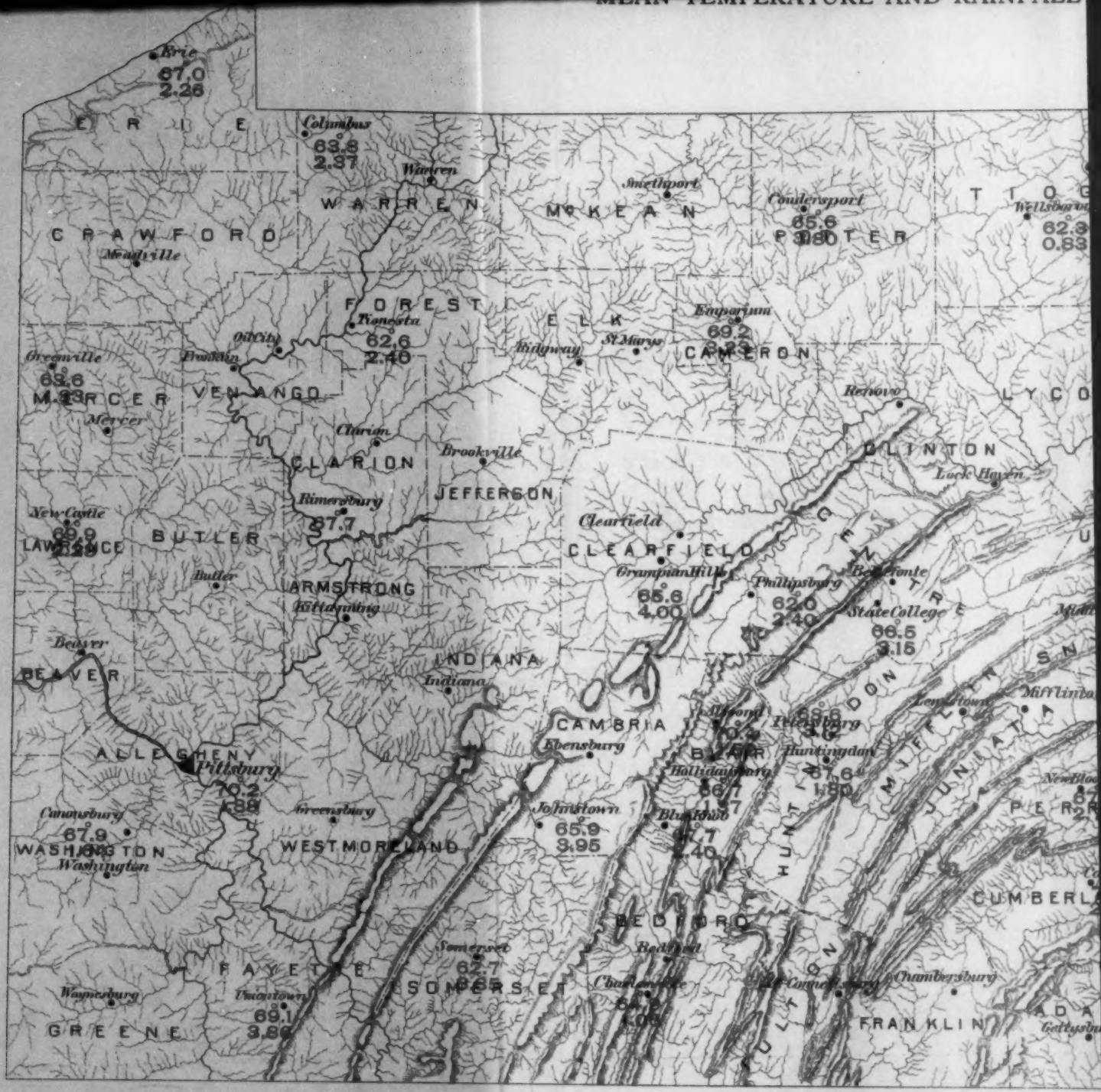
Precipitation.		Number of Days.			Wind.			Observers.
					Prevailing Direction.			
Total Inches.	Number of Days Rainfall.	Clear.	Fair.	Cloudy.	7 A. M.	2 P. M.	9 P. M.	
1·88	6	9	15	7	N	. . .	N	Oscar D. Stewart, Sgt. Sig. Corps
1·06	7	10	12	3	SW	W	S	Rev. A. Thos. G. Apple.
4·46	8	17	7	7	SW	. . .	SW	C. M. Dechant, C.E.
1·52	7	. . .	. . .	. . .	. . .	. . .	. . .	Dr. Charles B. Dudley.
2·40	9	14	10	7	NW	NW	NW	A. H. Boyle.
1·37	9	17	12	2	W	W	W	Prof. J. A. Stewart.
2·07	8	9	10	12	E	W	W	Charles Beecher.
2·08	7	. . .	. . .	. . .	SW	. . .	. . .	Geo. W. T. Warburton.
5·30	8	14	10	7	W	W	W	J. C. Hillman.
4·76	10	12	13	6	SW	NE	SW	J. L. Meacock.
3·95	8	24	6	1	SE	SE	SE	E. C. Lorentz.
3·23	6	11	19	1	NW	NW	W	T. B. Lloyd
3·15	7	15	13	3	W	W	W	Prof. Wm. Frear.
2·40	8	. . .	. . .	. . .	SW	SW	SW	Geo. H. Dunkle.
4·43	11	15	12	4	W	SW	SW	Jesse C. Green, D.D.S.
3·05	10	16	9	6	W	S	W	W. T. Gordon.
. . .	4	20	5	6	SW	W	W	Rev. W. W. Deatrick, A.M.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	C. M. Thomas, B.S.
4·00	13	13	12	6	W	W	W	Nathan Moore.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Prof. John A. Robb.
6·17	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Robert M. Graham.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	R. B. Derickson.
2·49	7	14	12	5	S	S	W	J. E. Pague.
3·58	10	15	12	4	W	W	W	Frank Ridgway, Sgt. Sig. Corps.
3·52	8	1	17	13	NW	NW	NW	Prof. Susan J. Cunningham.
2·26	6	16	8	7	SW	SW	SW	Peter Wood, Sgt. Sig. Corps.
3·86	7	18	12	1	NW	NW	NW	Wm. Hunt.
2·40	4	4	11	16	W	W	W	R. L. Haslet.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Thomas F. Sloan.
1·80	5	18	10	3	W	. . .	W	Prof. W. J. Swigart.
3·12	8	18	7	6	W	W	W	J. E. Rooney.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Prof. Albert E. Maltby.
2·28	8	14	9	8	W	W	W	Wm. T. Butz.
3·07	6	22	5	4	W	W	W	Wm. H. Kline.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Geo. W. Bowman, A.M., Ph.D.
4·77	8	. . .	. . .	. . .	. . .	. . .	. . .	H. D. Miller, M.D.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Armstrong & Brownell.
1·83	7	18	4	9	SE	. . .	SE	Prof S. H. Miller.
5·05	7	21	3	7	W	W	W	Charles Moore, D.D.S.
4·10	9	22	4	5	W	W	W	Lerch & Rice.
2·75	8	16	8	7	NE	NE	NE	Frank Mortimer.
7·07	12	13	6	12	SW	SW	SW	Luther M. Dey, Sgt. Sig. Corps.
3·80	6	22	5	4	N	N	N	C. L. Peck.
6·03	10	17	12	2	W	W	W	E. C Wagner.
6·00	6	20	8	3	NW	NW	SW	J. M. Boyer,
3·35	6	20	9	2	NW	NW	NW	W. M. Schrock.
2·82	7	15	9	7	SW	SW	SW	E. S. Chase.
·83	8	10	12	9	N	N	N	H. D. Deming.
2·37	11	14	14	3	SW	SW	SW	Wm. Loveland.
1·64	8	22	7	3	S	SW	SW	A. L. Runion.
2·85	7	13	13	5	W	W	W	Theodore Day.
2·60	. . .	. . .	. . .	. . .	. . .	. . .	. . .	John Torrey.
2·83	8	19	9	3	NW	. . .	NW	Mrs. L. H. Grenewald.

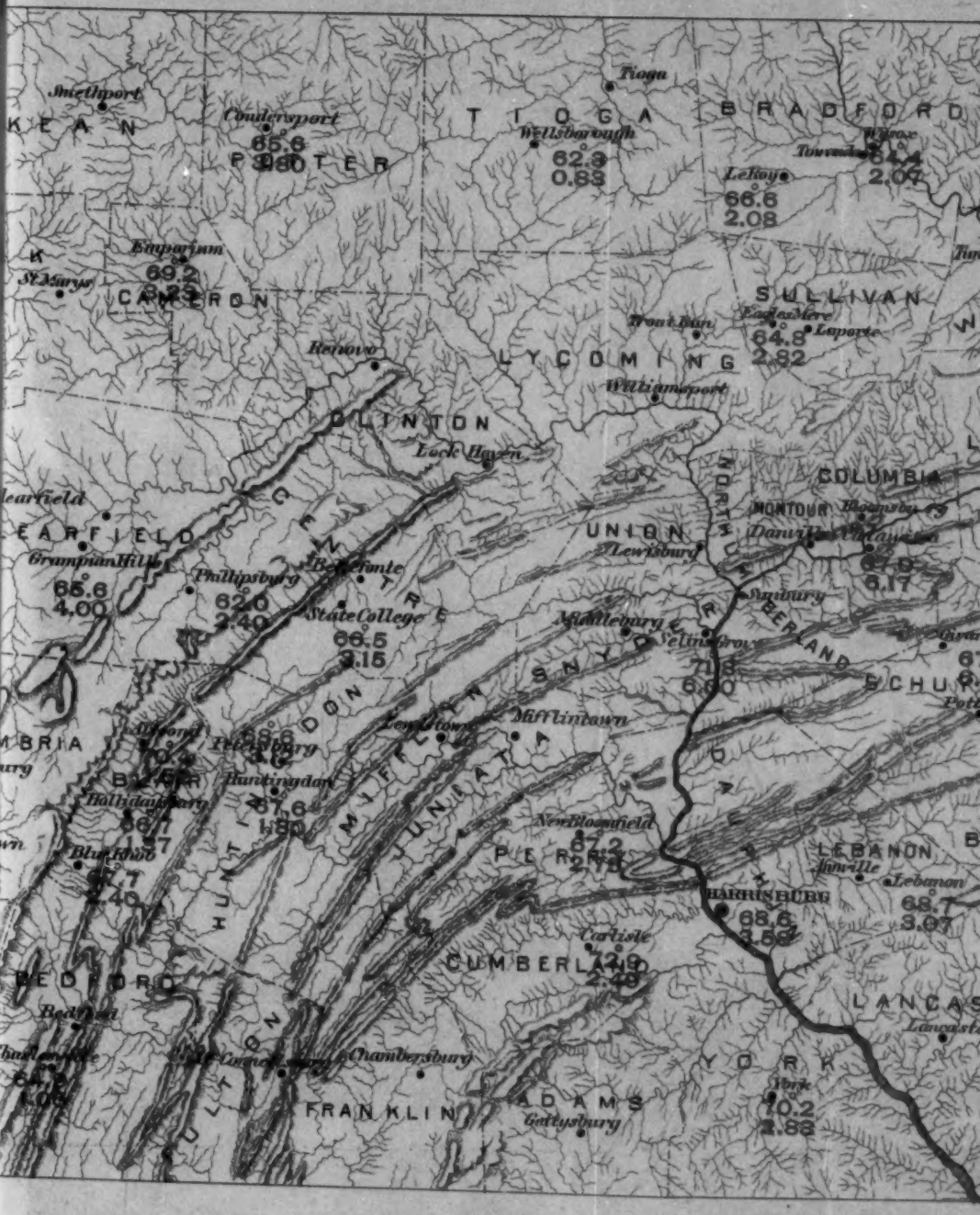
T. F. TOWNSEND, *Sergeant Signal Corps, Assistant.*

ISOTHERMAL LINE

SHOWING THE

NORMAL TEMPERATURE OF PENNSYLVANIA


Erie
67.0
2.26
ERIE
Columbus
63.8
2.37
Warren
WARREN
McKEAN
Smethport
Coudersport
65.6
POTTER
62.3
0.83
CRAWFORD
Meadville
FOREST
ELK
Emporium
69.2
Tionesta
62.6
2.40
Oil City
Ridgway
St Marys
CAMERON
Greenville
63.6
MERCER
VENANGO
Franklin
Mercer
Clarion
Brookville
CLARION
JEFFERSON
Rimersburg
67.7
New Castle
69.9
LAWRENCE
BUTLER
Clearfield
CLEARFIELD
Grampian Hills
65.6
4.00
Phillipsburg
62.0
2.40
State College
66.5
3.15
Butler
ARMSTRONG
Kittanning
Beaver
BEAVER
INDIANA
Indiana
CAMBRIA
Ebensburg
Johnstown
65.9
3.95
Huntingdon
67.6
1.80
Pittsburg
70.2
1.88
ALLEGHENY
Greensburg
Connellsburg
67.9
WASHINGTON
WESTMORELAND
Washington
Somerset
62.7
SOMERSET
FAYETTE
Uniontown
69.1
3.86
Waynesburg
GREENE
BEDFORD
Bedford
Chambersburg
FRANKLIN
CUMBERLAND
JUNIATA
PERRY
Lewistown
Mifflintown
Tyrone
Altoona
Bellefonte
CENTRE
CLINTON
Lock Haven
Renovo
LYCOMING
Wellsboro
62.3
0.83


Smethport
KEAN
Coudersport
65.6
POTTER
TIOGA
Tioga
Wellsborough
62.3
0.83
BRADFORD
Towanda
64.4
2.04
LeRoy
66.6
2.08
Emporium
69.2
St Marys
CAMERON
SULLIVAN
Eagles Mere
64.8
2.82
Laporte
Renovo
LYCOMING
Williamsport
CLINTON
Lock Haven
COLUMBIA
MONTOUR
Bloomsburg
Danville
67.0
3.17
Clearfield
CLEARFIELD
Grampian Hills
65.6
4.00
Phillipsburg
62.0
2.40
Bellefonte
State College
66.5
3.15
UNION
Lewisburg
Selinsgrove
71.8
6.00
SNYDER
Middleburg
Sunbury
NORTHUMBERLAND
Mifflintown
Lewistown
Altoona
Tyrone
Hollidaysburg
Huntingdon
Bedford
Blue Knob
Newport
Perry
New Bloomfield
87.2
2.78
HARRISBURG
68.6
3.58
LEBANON
Annville
Lebanon
68.7
3.07
Carlisle
71.9
2.48
CUMBERLAND
PERRY
JUNIATA
MIFFLIN
CENTRE
HUNTINGDON
BLAIR
CAMBRIA
Ebensburg
Johnstown
Somerset
Bedford
Chambersburg
FRANKLIN
ADAMS
Gettysburg
YORK
York
10.2
2.88
LANCASTER
Lancaster

SUSQUEHANNA
WAYNE
Montrose
Honesdale
62.0
2.60
Tunkhannock
South Eaton
Scranton
Bloomsburg Grove
Milford
PIKE
Wilkesbarre
LUZERNE
MONROE
Stroudsburg
Drifton
64.1
4.77
CARBON
Mauch Chunk
NORTHAMPTON
Girardville
67.9
Easton
Pottsville
Lynnport
Bethlehem
LEHIGH
Allentown
4.10
Hamburg
Quakertown
87.7
BUCKS
Doglestown
Lebanon
68.7
3.07
Reading
67.3
4.46
MONTGOMERY
Pottstown
72.0
6.05
Norristown
LANCASTER
Lancaster
CHESTER
West Chester
69.9
4.42
DELAWARE

CRAWFORD
FORREST
VENANGO
MERCER
CLARION
BUTLER
ARMSTRONG
BEAVER
WESTMORELAND
WASHINGTON
GREENE

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
Chester Oil Company,	Chester.
C. W. Burkhart,	Shoemakerville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Werner & Son,	Emporium.
C. E. Lenhart,	Latrobe.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
S. W. Morrison,	Oxford.
Capt. A. Goldsmith,	Quakertown.
J. L. Morrison,	Sharon.
Wm. A. Engel,	Shenandoah.
Wm. Schrock,	Somerset.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
E. H. Baker,	Williamsport.
New Era,	Lancaster.
State Normal School,	Clarion.
Clarion Collegiate Institute,	Rimersburg.
E. S. Chase,	Eagles Mere.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
J. E. Forsythe,	Butler.
James H. Fones,	Tionesta.
Wister, Hacker & Savage,	Germantown.
W. J. Thompson & Co.,	Clifton Heights.
Steward M. Dreher,	Stroudsburg.

Displayman.	*Station.*
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
Hartford P. Brown,	Rochester.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
Smith Curtis,	Beaver.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. J. Edelman,	Pottstown.
A. M. Wildman,	Langhorn.
N. E. Graham,	East Brady.
B. F. Gilmore,	Chambersburg.
Frank M. Morrow,	Altoona.
A. Simon's Sons,	Lock Haven.
E. W. McArthurs,	Meadville.
J. K. M. McGovern,	Lock No. 4.
Raftsman's Journal,	Clearfield.
W. S. Ravenscroft,	Hyndman.
R. C. Schmidt & Co.,	Belle Vernon.
Jesse R. Brown,	Lehmasters.
H. W. Mullen,	Centre Valley.
Mayer Bros.,	Bloomsburg.

PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR SEPTEMBER, 1889.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE.

PHILADELPHIA, September 30, 1889.

TEMPERATURE.

The mean temperature for the month of September, 1889, deduced from the reports of fifty stations, was 61°·9, which is about one degree above the normal, and two degrees above that of September, 1888. The greatest departures were in the southeastern part of the State. The means of the daily maximum and minimum temperatures were 70°·8 and 53°·0, respectively, making a daily mean of 61°·9, and an average daily range of 17°·8.

The highest temperatures recorded were Columbus, 92°; Lebanon, 91°; Petersburg, 90°; Greenville, 90°; New Castle, 90°, and Pittsburgh, 90°.

The lowest were Pillipsburg, 30°; Clarion, 31°; Petersburg, 31°; New Castle, 31°; Coudersport, 31°; Columbus, 31°, and Dyberry, 31°.

The highest temperatures occurred on the 1st and 2d, and the lowest on the 23d.

Frosts were general on the 23d.

Stations with the highest monthly averages were Myerstown, 68°·7; Philadelphia, 66°·4; Pottstown, 65°·0, and Uniontown, 64°·9.

The lowest averages were Dyberry, 57°·2; South Eaton, 57°·5; Phillipsburg, 57°·7; Eagles Mere, 58°·2, and Wellsboro, 58°·4.

BAROMETER.

The average pressure, 30·04, is slightly below the normal. The lowest occurred on the 20th and 21st. The range for the State was about one inch.

PRECIPITATION.

The average precipitation for the State, 5·05 inches, is an excess of 1·50 inches. The greatest departures were in the eastern part of the State, where

the following totals in inches were reported: Kennett Square, 10·01; West Chester, 9·95; Eagles Mere, 9·35; Coatesville, 9·12; Forks of Neshaminy, 8·76, and Doylestown, 8·61. The smallest totals were Wellsboro, 2·71; Altoona, 2·74; Grampian Hills, 2·76; Emporium, 2·84, and Somerset, 2·94. The heavy rains, from the 10th to the 15th, did not extend to the extreme western part of the State. A few stations reported light snow on the 19th, 20th and 21st.

NOTE.—Observers are particularly requested to enter the time of the beginning and ending of precipitation. Also to note *excessive precipitation.*

Excessive precipitation is an actual fall of 2·50 inches or over in twenty-four hours, or one inch or more in one hour.

WIND AND WEATHER.

The notable West Indian hurricane, which occasioned the destructive floods along the seaboard of New Jersey from the 9th to the 12th, caused high winds and heavy rains throughout the eastern and middle portions of Pennsylvania. The whole month may be characterized as wet and unpleasant. The dampness caused considerable delay in wheat seeding, and rotted potatoes so badly that only a very small crop was secured.

Average Number.—Rainy days, 13; clear days, 8; fair days, 8; cloudy days, 14.

Prevailing Direction of Wind.—West.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Pittsburgh, 3d, 4th; Blue Knob, 3d, 16th; Quakertown, 17th; State College, 16th; West Chester, 6th, 15th, 16th, 17th, 19th; Coatesville, 14th, 16th, 17th; Rimersburg, 3d, 4th; Catawissa, 15th, 16th; Uniontown, 3d, 4th; Petersburg, 16th; Indiana, 4th; New Castle, 11th; Myerstown, 6th, 16th; Annville, 16th; New Bloomfield, 15th, 16th; Philadelphia, 16th, 17th; Girardville, 16th; Selins Grove, 16th; Somerset, 6th, 16th; Canonsburg, 10th; York, 16th; Lancaster, 16th; Wilkes-Barre, 16th; Kennett Square, 16th.

Frost.—Blue Knob, 18th, 23d, 28th; Hollidaysburg, 23d; Le Roy, 22d, 27th; Quakertown, 23d; Emporium, 23d; Phillipsburg, 23d; West Chester, 23d, 28th; Coatesville, 23d; Rimersburg, 23d; Grampian Hills, 23d; Catawissa, 23d; Harrisburg, 23d; Uniontown, 23d, 28th; Petersburg, 23d; New Castle, 23d; Myerstown, 23d, 24th, 27th, 29th; Greenville, 28th; Philadelphia 23d; Girardville, 20th, 26th; Selins Grove, 23d; Somerset, 18th, 23d, 28th; Eagles Mere, 23d, 28th, 29th; Wellsboro, 23d, 28th; Columbus, 23d; Canonsburg, 23d; Dyberry, 23d, 29th; Honesdale, 23d, 29th; York, 23d, 29th; Lancaster, 23d, 27th; Wilkes-Barre, 23d; South Eaton, 23d.

Hail.—Blue Knob, 21st; Quakertown, 21st; Bethlehem, 19th, 21st; Philadelphia, 1st; Girardville, 19th; Selins Grove, 21st.

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Se

County.	Station.	Elevation above Sea Level (feet).	Barometer.			Temperature.													Relative Humidity.	Dew Point.	Preci
			Mean.	Highest.	Lowest.	Mean.	Maximum.		Minimum.		Mean of Maximum.	Mean of Minimum.	Daily Range.								
							Highest.	Date.	Lowest.	Date.			Mean.	Greatest.	Date.	Least.	Date.				Total Inches.
Allegheny,[1]	Pittsburgh,	847	30·028	30·244	29·495	65·6	90·0	1	44·0	23	73·6	57·5	16·1	29·0	. . .	6·0	. . .	73·3	54·9	2·87
Bedford,	Charlesville,	1,300	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Berks,[1]	Reading,	304	30·056	30·279	29·636	63·5	84·0	2, 16	42·0	22, 27	73·0	54·1	18·9	34·0	2	8·0	12	89·2	63·8	7·08
Blair,[2]	Altoona,	1,181	. . .	. . .	. . .	64·4	86·0	6	41·0	23	72·5	56·2	16·3	26·0	1	5·0	15	. . .	. . .	2·74
Blair,	Blue Knob,	2,100	. . .	. . .	. . .	60·0	86·0	5	38·0	21	65·8	55·4	10·4	18·0	1	6·0	21	. . .	. . .	4·70
Blair,	Hollidaysburg,	947	. . .	. . .	. . .	62·0	87·0	1, 3	32·0	23	73·6	50·8	22·8	40·0	23	11·0	13	84·7	57·6	3·01
Bradford,	Wysox,	718	30·049	30·327	29·494	60·2	86·0	3	32·5	23	70·2	50·2	20·0	35·5	3	8·0	17	84·3	55·1	3·21
Bradford,	Le Roy,	875	. . .	. . .	. . .	59·8	84·0	4	37·0	27	67·3	52·9	14·4	25·0	23	5·0	21	. . .	. . .	3·13
Bucks,	Forks of Neshaminy,	. . .	. . .	. . .	. . .	61·9	82·0	6	48·0	23, 29	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	8·76
Bucks,	Quakertown,	536	30·040	30·320	29·510	61·6	84·0	6	36·7	23	72·2	53·5	18·7	34·2	3	4·3	12	86·4	57·4	8·06
Cambria,	Johnstown,	1,184	. . .	. . .	. . .	62·8	85·0	1, 3	42·0	27, 29	71·3	54·3	17·0	30·0	29	10·0	17	. . .	. . .	4·59
Cameron,	Emporium,	1,030	. . .	. . .	. . .	62·9	84·0	3, 4	35·0	23	71·4	50·5	20·9	34·0	29	8·0	17	. . .	. . .	2·84
Centre,	State College— Agricultural Experiment Station,	1,191	30·023	30·298	29·454	60·6	81·0	1, 3	36·0	23	68·3	51·7	16·6	31·0	23	7·0	17	76·2	54·2	3·67
Centre,	Phillipsburg,	1,350	. . .	. . .	. . .	57·7	85·0	3	30·0	23	69·7	49·8	19·9	40·0	23	7·0	17	. . .	. . .	2·91
Chester,	West Chester,	455	30·029	30·314	29·515	62·6	84·0	6	42·0	23	70·7	56·6	14·1	25·0	29	4·0	12	81·0	56·5	9·95
Chester,	Coatesville,	380	. . .	. . .	. . .	62·9	88·0	6	37·0	23	73·5	57·4	16·1	36·0	23	4·0	12	. . .	. . .	9·12
Chester,[1]	Kennett Square,	275	. . .	. . .	. . .	62·8	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	10·01
Clarion,	Rimersburg,	1,500	. . .	. . .	. . .	61·9	87·0	1	40·0	28	68·6	56·0	12·6	24·0	23	1·0	20	. . .	. . .	. . .
Clarion,	Clarion— State Normal School,	1,530	. . .	. . .	. . .	61·8	86·5	1	31·0	23	69·7	50·7	19·0	45·0	1	3·0	21	79·6	55·3	3·32
Clearfield,	Grampian Hills,	1,450	. . .	. . .	. . .	60·4	86·0	1	32·0	23	68·8	54·0	14·8	29·0	3	6·0	20	. . .	. . .	2·76
Clinton,	Lock Haven,	560	. . .	. . .	. . .	62·9	87·0	1	36·0	23	72·1	53·0	19·1	39·0	23	7·0	17	. . .	. . .	4·73
Columbia,	Catawissa,	491	. . .	. . .	. . .	63·3	80·5	1, 16	39·0	23	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4·47
Crawford,	Meadville— Allegheny College,	1,050	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Cumberland,	Carlisle,	480	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Dauphin,[1]	Harrisburg,	361	30·068	30·322	29·559	62·6	82·0	16	43·8	23	70·3	57·3	13·0	25·0	23	4·0	12	80·6	56·2	4·53
Delaware,	Swarthmore— Swarthmore College,	190	30·023	30·383	29·615	63·8	85·0	6	41·0	23	72·1	56·4	15·7	29·5	23	3·5	12	82·6	58·6	8·04
Erie,[1]	Erie,	681	30·032	30·265	29·466	63·0	85·0	2, 15	42·0	23	69·0	56·0	13·0	25·0	29	3·0	16	76·0	54·0	4·85
Fayette,	Uniontown,	1,000	30·000	30·177	27·039	64·9	89·0	1	38·0	23	73·3	55·4	17·9	34·0	23	6·0	6	79·4	58·5	3·79
Forrest,	Tionesta,	1,057	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Franklin,[1]	Chambersburg— Wilson Female College,	618	30·009	30·339	29·597	62·9	86·0	15, 17	34·0	23	71·6	54·2	17·4	35·0	23	6·0	12	86·1	57·5	4·13
Fulton,	McConnellsburg,	875	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Huntingdon,[1]	Huntingdon— The Normal College,	650	. . .	. . .	. . .	62·6	87·2	1	35·0	23	76·5	53·9	22·6	38·0	26	9·0	25	. . .	. . .	4·53
Huntingdon,	Petersburg,	700	. . .	. . .	. . .	61·1	90·0	1	31·0	24	71·1	52·5	18·6	37·0	3	3·0	6	. . .	. . .	3·57
Indiana,	Indiana— State Normal School,	1,350	. . .	. . .	. . .	61·7	87·6	1	35·0	23	71·1	50 6	20·5	36·7	28	10·0	14	81·3	55·9	4·06
Lancaster,	Lancaster,	413	30·023	30·197	29·621	62·8	87·0	4	39·0	23	71·9	54·7	17·2	38·0	4	6·0	12	90·9	60·5	6·38
Lawrence,	New Castle,	932	. . .	. . .	. . .	63·1	90·0	1, 2	31·0	23	74·1	50·1	24·0	40·0	23	7·0	20	. . .	. . .	4·01
Lebanon,	Myerstown,	474	30·017	30·261	29·531	61·9	87·9	9	36·5	23	72·7	54·4	18·3	34·5	23	5·1	12	87·7	57·3	3·45
Lebanon,	Annville— Lebanon Valley College,	339	. . .	. . .	. . .	68·7	91·0	9	50·0	29	. . .	. . .	. . .	. . .	. . .	. . .	. . .	80·8	63·5	. . .
Luzerne,	Drifton— Drifton Hospital,	1,655	. . .	. . .	. . .	58·9	78·0	15	40·0	22, 23	67·2	52·7	14·5	28·0	3	7·0	12	. . .	. . .	5·56
Luzerne,[1]	Wilkes-Barre (24 days),	575	. . .	. . .	. . .	60·5	82·0	16	37·0	23	67·0	54·0	13·0	32·0	23	3·0	12	. . .	. . .	5·79
Mercer,[1]	Greenville— Thiel College,	1,000	30·030	30·262	29·426	59·3	90·3	2	33·8	23	73·1	55·3	17·8	37·4	7	5·7	30	92·5	56·5	3·68
Montgomery,	Pottstown,	150	. .	. . .	. . .	65·0	88·0	6	41·0	23	73·0	58·0	15·0	29·0	23	3·0	12	84·0	60·0	8·44
Northampton,	Bethlehem,	360	. . .	. . .	. . .	64·0	83·0	6	40·0	29	72·0	56·0	16·0	30·0	2	8·0	12	80·0	58·0	6·14
Perry,	New Bloomfield,	400	. . .	. . .	. . .	61·3	88·0	1	34·0	23	72·0	54·0	18·0	39·0	23	3·0	17	. . .	. . .	5·02
Philadelphia,[1]	Philadelphia,	117	30·046	30·330	29·330	66·4	87·0	6	47·0	22	73·4	59·5	13·9	22·0	23	4·0	12	80·0	60·0	4·66
Potter,	Coudersport,	1,670	. . .	. . .	. . .	60·5	88·0	30	31·0	23	69·7	47·2	22·5	33·0	4	4·0	20	90·0	56·5	2·90
Schuylkill,	Girardville,	1,000	30·066	30·318	29·631	61·3	80·0	16	37·0	23	69·0	52·5	16·5	28·0	29	8·0	11	. . .	. . .	6·50
Snyder,	Selins Grove,	445	. . .	. . .	. . .	63·1	84·0	3	41·0	23	73·6	53·0	20·6	39·0	1	28·0	30	79·0	58·0	5·16
Somerset,	Somerset,	2,230	. . .	. . .	. . .	57·0	88·0	1	32·0	23	69·9	50·0	19·9	34·0	23	7·0	24	83·0	54·0	2·94
Sullivan,	Eagles Mere,	2,060	30·102	30·438	29·568	58·2	74·0	16	36·0	23	63·8	50·5	13·3	22·0	23	3·0	19	80·7	51·8	9·35
Tioga,	Wellsboro,	1,327	30·024	30·325	29·439	58·4	88·0	4	30·0	23	69·9	51·1	18·8	18·0	1	8·0	4	69·2	48·3	2·71
Warren,	Columbus,	1,410	. . .	. . .	. . .	61·0	90·0	1, 2	31·0	23	72·2	49·8	22 4	46·0	1	2 0	16	83·1	53·2	5·25
Washington,	Canonsburg,	950	. . .	. . .	. . .	62·5	88·0	1, 2	36·0	22	73·0	52·0	21·0	40·0	23	16·0	30	73·0	55·0	3·41
Wayne,	Dyberry,	1,100	. . .	. . .	. . .	57·2	82·0	16	31·0	29	68·4	48·7	19·7	36·0	3	5·0	12	. . .	. . .	4·18
Wayne,	Honesdale,	1,000	. . .	. . .	. . .	60·1	80·0	16	34·0	23	68·0	55·2	12·8	28·0	23	5·0	19	76·0	58·0	5·90
Wyoming,[1]	South Eaton (27 days),	660	. . .	. . .	. . .	57·5	80·1	5	32·0	23	65·2	49·8	15·4	31·8	23	3·0	13	. . .	. . .	3·32
York,[1]	York,	385	30·056	30·340	29·605	63·4	85·0	4	38·5	23	73·4	55·5	17·9	38·5	23	5·0	12	78·3	57·7	6 87

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

TEMPERATURE.												PRECIPITATION.		N
M.	MINIMUM.				DAILY RANGE.					RELATIVE HUMIDITY.	DEW POINT.			
Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.	Least.	Date.			Total Inches.	Number of Days Rainfall.	Clear.
1	44·0	23	73·6	57·5	16·1	29·0	. . .	6·0	. . .	73·3	54·9	2·87	11	9
. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
, 16	42·0	22, 27	73·0	54·1	18·9	34·0	2	8·0	19	89·4	63·8	7·08	10	9
6	41·0	23	72·5	56·2	16·3	26·0	1	5·0	15	. . .	. . .	2·74	11	. .
5	38·0	21	65·8	55·4	10·4	18·0	1	6·0	21	. . .	. . .	4·70	18	5
, 3	32·0	23	73·6	50·8	22·8	40·0	23	11·0	13	84·7	57·6	3·01	15	10
3	32·5	23	70·2	50·2	20·0	35·5	3	8·0	17	84·3	55·1	3·21	12	7
4	37·0	27	67·3	52·9	14·4	25·0	23	5·0	21	. . .	. . .	3·13	12	7
6	48·0	23, 29	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	8·76	8	9
6	36·7	23	72·2	53·5	18·7	34·2	3	4·3	19	88·4	57·4	8·06	15	6
, 3	42·0	27, 29	71·3	54·3	17·0	30·0	29	10·0	17	. . .	. . .	4·59	9	. .
, 4	35·0	23	71·4	50·5	20·9	34·0	29	8·0	17	. . .	. . .	2·84	9	5
, 3	36·0	23	68·3	51·7	16·6	31·0	23	7·0	17	76·2	54·2	3·67	14	5
3	30·0	23	69·7	49·8	19·9	40·0	23	7·0	17	. . .	. . .	2·91	16	3
6	42·0	23	70·7	56·6	14·1	25·0	29	4·0	12	81·0	56·5	9·95	18	11
6	37·0	23	73·5	57·4	16·1	30·0	23	4·0	12	. . .	. . .	9·12	17	12
. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	10·01	17	9
1	40·0	28	68·6	56·0	12·6	24·0	23	1·0	20	. . .	. . .	. . .	10	7
1	31·0	23	69·7	50·7	19·0	45·0	1	3·0	21	79·6	55·3	3·32	5	13
1	32·0	23	68·8	54·0	14·8	29·0	3	6·0	20	. . .	. . .	2·76	14	4
1	36·0	23	72·1	53·0	19·1	39·0	23	7·0	17	. . .	. . .	4·73	15	9
, 16	39·0	23	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4·47	11	. .
. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
16	43·8	23	70·3	57·3	13·0	25·0	23	4·0	12	80·6	56·2	4·53	17	8
6	41·0	23	72·1	56·4	15·7	29·5	23	3·5	12	82·6	58·6	8·04	11	1
, 15	42·0	23	69·0	56·0	13·0	25·0	29	3·0	16	76·0	54·0	4·85	15	10
1	38·0	23	73·3	55·4	17·9	34·0	23	6·0	6	79·4	58·5	3·79	11	12
. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
, 17	34·0	23	71·6	54·2	17·4	35·0	23	6·0	12	86·1	57·5	4·13	8	. .
. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .
1	35·0	23	76·5	53·9	22·6	38·0	26	9·0	25	. . .	. . .	4·53	9	11
1	31·0	24	71·1	52·5	18·6	37·0	3	3·0	6	. . .	. . .	3·57	11	6
1	35·0	23	72·1	50 6	20·5	36·7	28	10·0	14	81·3	53·9	4·06	17	5
4	39·0	23	71·9	54·7	17·2	38·0	4	6·0	12	90·9	60·5	6·38	15	5
, 2	31·0	23	74·1	50·1	24·0	40·0	23	7·0	20	. . .	. . .	4·01	10	8
9	36·5	23	72·7	54·4	18·3	34·5	23	5·1	12	87·7	57·3	3·45	15	8
9	50·0	29	. . .	. . .	. . .	. . .	. . .	. . .	. . .	80·8	63·5	. . .	. . .	4
15	40·0	22, 23	67·2	52·7	14·5	28·0	3	7·0	12	. . .	. . .	5·56	17	. .
10	37·0	23	67·0	54·0	13·0	32·0	23	3·0	12	. . .	. . .	5·79	13	5
2	33·8	23	73·1	55·3	17·8	37·4	7	5·7	30	92·5	56·5	3·68	12	8
6	41·0	23	73·0	58·0	15·0	29·0	23	3·0	12	84·0	60·0	8·44	9	11
6	40·0	29	72·0	56·0	16·0	30·0	2	8·0	12	80·0	58·0	6·14	17	14
1	34·0	23	72·0	54·0	18·0	39·0	23	3·0	17	. . .	. . .	3·08	16	7
6	47·0	22	73·4	59·5	13·9	22·0	23	4·0	12	80·0	60·0	4·66	17	7
20	31·0	23	69·7	47·2	22·5	33·0	4	4·0	20	90·0	56·5	2·90	6	8
16	37·0	23	69·0	52·5	16·5	28·0	29	8·0	11	. . .	. . .	6·50	17	8
3	41·0	23	73·0	33·0	40·6	59·0	1	28·0	20	79·0	58·0	5·16	10	4
1	32·0	23	69·9	50·0	19·9	34·0	23	7·0	24	83·0	54·0	2·94	10	10
16	36·0	23	63·8	50·5	13·3	22·0	23	3·0	19	80·7	51·8	9·35	14	8
4	30·0	23	69·9	51·1	18·8	18·0	1	2·0	4	69·2	48·3	2·71	14	6
, 2	31·0	23	72·2	49·8	22 4	46·0	1	2·0	16	83·1	53·2	5·95	11	10
, 2	36·0	22	73·0	52·0	21·0	42·0	23	16·0	30	73·0	55·0	3·41	11	10
16	31·0	29	68·4	48·7	19·7	36·0	3	5·0	12	. . .	. . .	4·18	12	5
16	34·0	23	68·0	55·2	12·8	28·0	23	5·0	12	76·0	58·0	5·90	18	. .
5	32·0	23	65·2	49·8	15·4	31·8	23	3·0	13	. . .	. . .	3·32	11	6
4	38·5	23	73·4	55·5	17·9	38·5	23	5·0	12	78·3	57·7	6·87	13	13

PITATION.	NUMBER OF DAYS.			WIND.			OBSERVERS.
				PREVAILING DIRECTION.			
Number of Days Rainfall.	Clear.	Fair.	Cloudy.	7 A. M.	2 P. M.	9 P. M.	
11	9	9	12	N	N	NE	Oscar D. Stewart, Sgt. Sig. Corps.
...	...	...	...	...	...	...	Rev. A. Thos. G. Apple.
10	9	5	16	NW	NW	NE	C. M. Dechant, C.E.
12	...	...	...	...	...	...	Dr. Charles B. Dudley.
18	5	5	20	NW	NW	NW	A. H. Boyle.
15	10	10	10	W	W	W	Prof. J. A. Stewart.
12	7	4	19	SE	SE	SE	Charles Beecher.
12	7	8	15	SW	SW	SW	Geo. W. T. Warburton.
8	9	8	13	NE	W	W	J. C. Hilsman.
15	6	10	14	NE	NE	NW	J. L. Heacock.
9	...	...	...	...	...	...	E. C. Lorentz.
9	5	14	11	W	W	E	T. B. Lloyd
14	5	7	18	W	SW	W	Prof. Wm. Frear.
16	3	7	20	SW	SW	SW	Geo. H. Dunkle.
18	11	7	12	N	NW	NW	Jesse C. Green, D.D.S.
17	12	3	15	W	S	W	W. T. Gordon.
17	9	6	15	N	N	S	Benj. P. Kirk.
10	7	12	11	E	W	E	Rev. W. W. Deatrick, A.M.
5	13	6	11	NE	SW	SW	C. M. Thomas, B.S.
14	4	8	18	W	W	W	Nathan Moore.
15	9	5	16	W	W	W	Prof. John A. Robb.
11	...	...	...	...	...	...	Robert M. Graham.
...	...	...	...	...	...	...	R. B. Derickson.
...	...	...	...	...	...	...	J. E. Pague.
17	8	7	15	W	W	W	Frank Ridgway, Sgt. Sig. Corps.
11	1	12	17	NW	SE	SW	Prof. Susan J. Cunningham.
15	10	9	11	S	S	S	Peter Wood, Sgt. Sig. Corps.
11	12	11	7	NW	SE	E	Wm. Hunt.
...	...	...	...	...	...	...	R. L. Haslet.
8	...	...	...	...	...	...	Miss Mary A. Ricker.
...	...	...	...	...	...	...	Thomas F. Sloan.
9	11	9	10	W	W	W	Prof. W. J. Swigart.
11	6	10	14	W	S	W	J. E. Rooney.
17	5	16	9	NE	NE	N	Prof. S. C. Schmucker.
15	5	12	13	SE	W	W	E. E. Weller.
10	8	12	10	SE	SE	SE	Wm. T. Butz.
15	8	5	17	E	E	E	Wm. H. Kline.
...	4	8	18	NW	NW	NW	Geo. W. Bowman, A.M., Ph.D.
17	...	...	...	...	...	...	H. D. Miller, M.D.
13	5	4	15	NW	NW	NW	A. W. Betterly.
12	8	7	15	SE	SE	NE	Prof. S. H. Miller.
9	11	7	13	NE	NE	NE	Charles Moore, D.D.S.
17	14	2	14	W	W	W	Lerch & Rice.
16	7	6	17	E	E	E	Frank Mortimer.
17	7	6	17	NE	NE	NE	Luther M. Dey, Sgt. Sig. Corps.
6	8	8	14	W	W	W	C. L. Peck.
17	8	1	21	W	NW	W	E. C. Wagner.
10	4	10	6	SW	SE	SE	J. M. Boyer,
10	10	11	9	NW	NW	NW	W. M. Schrock.
14	8	7	15	SW	SW	SW	E. S. Chase.
14	6	10	14	N	N	N	H. D. Deming.
11	10	9	11	SW	SW	SW	Wm. Loveland.
11	10	10	10	SE	NE	SE	A. L. Runion.
12	5	9	16	NW	NW	NW	Theodore Day.
18	...	...	...	...	...	...	John Torrey.
11	6	4	17	N	N	N	Benj. M. Hall.
13	13	3	14	NW	NW	NW	Mrs. L. H. Grenewald.

T. F. TOWNSEND, *Sergeant Signal Corps, Assistant.*

Snow.—Blue Knob, 20th, 21st; Phillipsburg, 19th; Selins Grove, 21st.

Coronæ.—Myerstown, 9th; Dyberry, 4th, 9th, 29th.

Aurora.—Blue Knob, 3d.

Solar Halos.—Le Roy, 29th; Wellsboro, 20th, 26th; Dyberry, 24th; South Eaton, 24th.

Lunar Halos.—Lock Haven, 26th; Annville, 9th; Somerset, 10th, 11th; Lancaster, 4th.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for September, 1889:

Weather, 88 per cent.

Temperature, 89 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

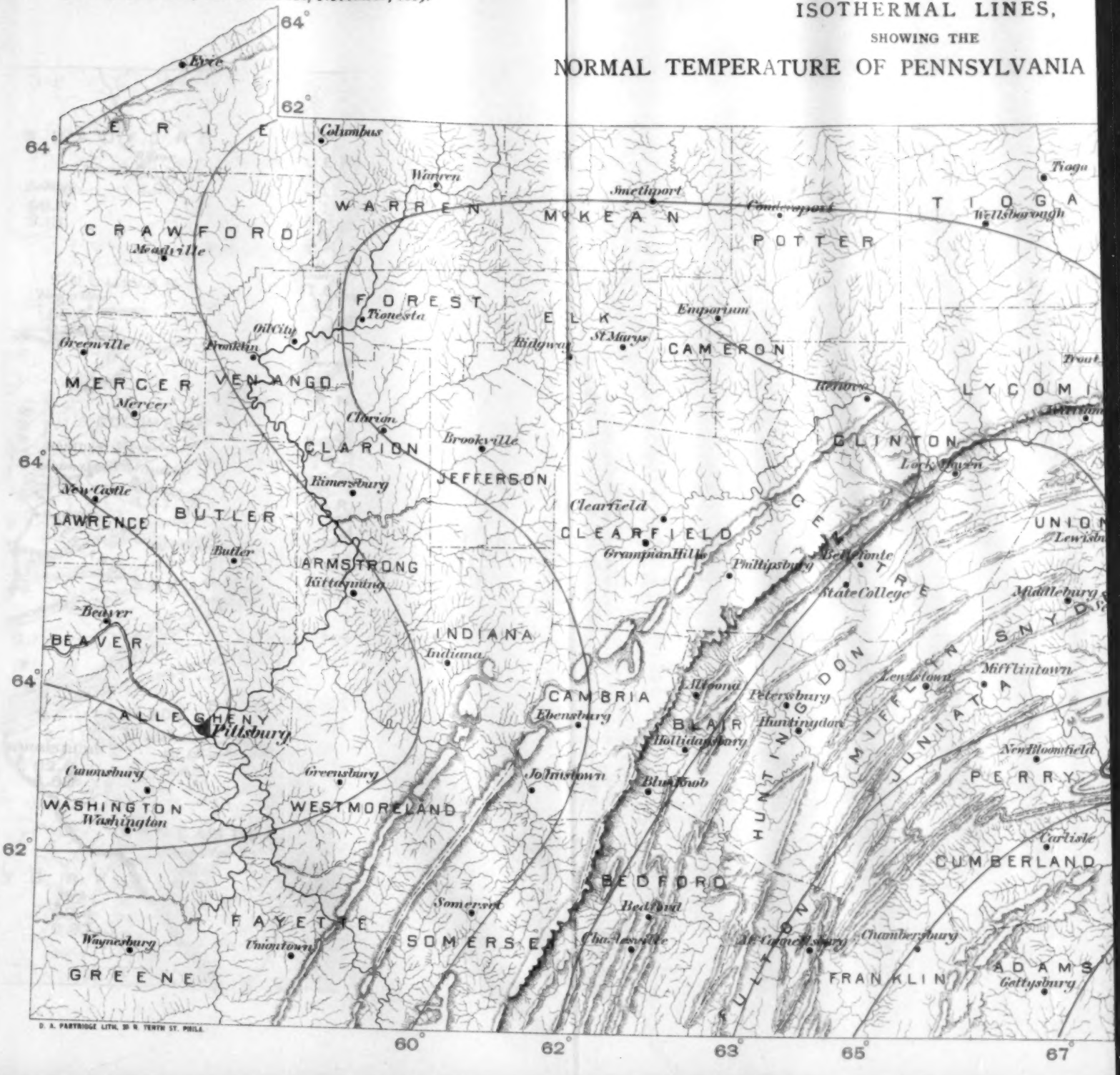
Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
Chester Oil Company,	Chester.
C. W. Burkhart,	Shoemakerville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Werner & Son,	Emporium.
C. E. Lenhart,	Latrobe.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
S. W. Morrison,	Oxford.
Capt. A. Goldsmith,	Quakertown.
J. L. Morrison,	Sharon.
Wm. A. Engel,	Shenandoah.
Wm. Schrock,	Somerset.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.

Displayman.	*Station.*
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
E. H. Baker,	Williamsport.
New Era,	Lancaster.
State Normal School,	Clarion.
Clarion Collegiate Institute,	Rimersburg.
E. S. Chase,	Eagles Mere.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
J. E. Forsythe,	Butler.
James H. Fones,	Tionesta.
Wister, Hacker & Savage,	Germantown.
W. J. Thompson & Co.,	Clifton Heights.
Steward M. Dreher,	Stroudsburg.
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
Hartford P. Brown,	Rochester.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
Smith Curtis,	Beaver.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. J. Edelman,	Pottstown.
A. M. Wildman,	Langhorn.
N. E. Graham,	East Brady.
B. F. Gilmore,	Chambersburg.
Frank M. Morrow,	Altoona.
A. Simon's Sons,	Lock Haven.
E. W. McArthurs,	Meadville.
J. K. M. McGovern,	Lock No. 4.
Raftsman's Journal,	Clearfield.
W. S. Ravenscroft,	Hyndman.
R. C. Schmidt & Co.,	Belle Vernon.
Jesse R. Brown,	Lehmasters.
H. W. Mullen,	Centre Valley.
Mayer Bros.,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. James,	Ashland.
Miller & Allison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.

ISOTHERMAL LINES,

SHOWING THE

NORMAL TEMPERATURE OF PENNSYLVANIA

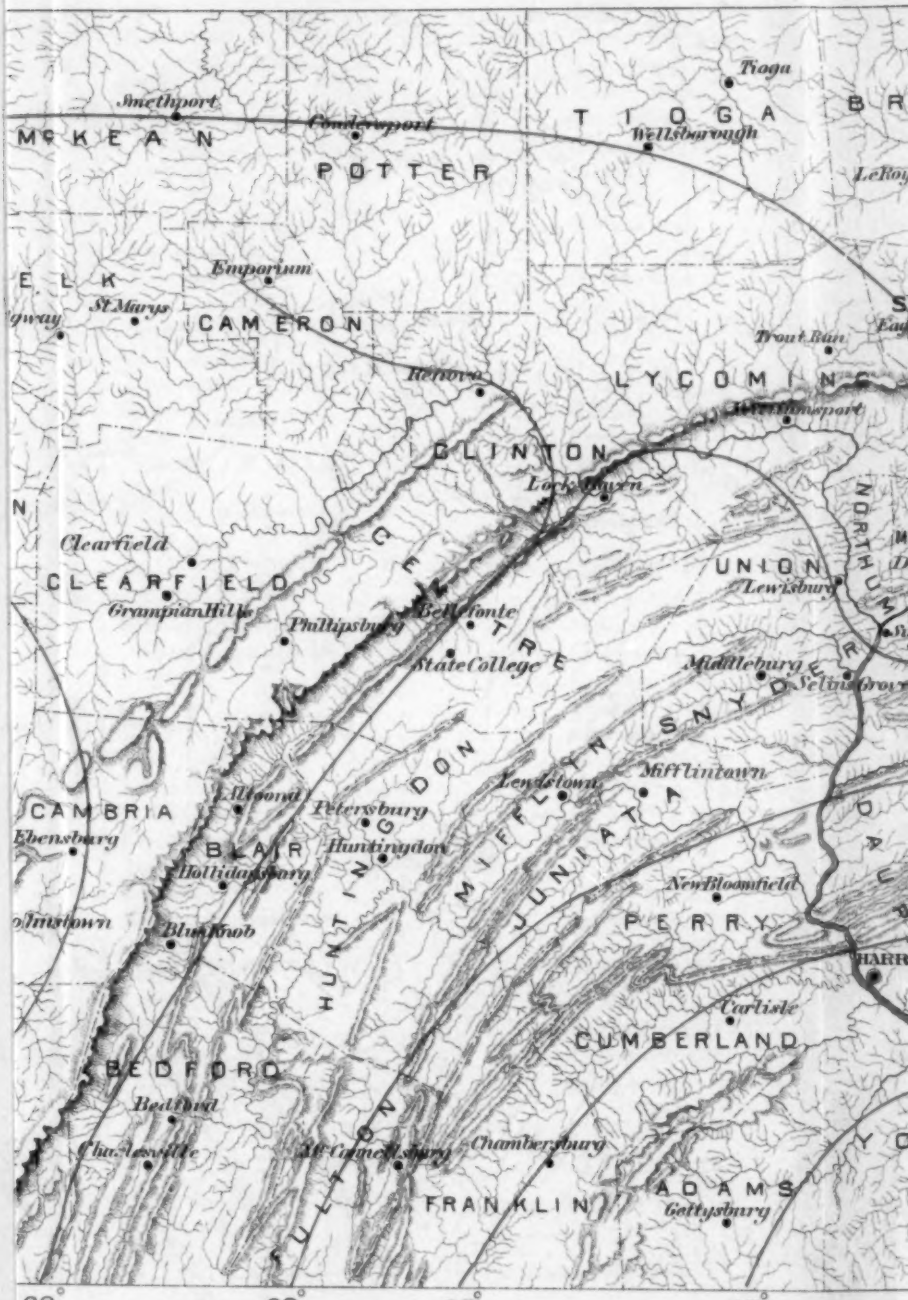


D. A. PARYRIDGE LITH. 20 S. TENTH ST. PHILA.

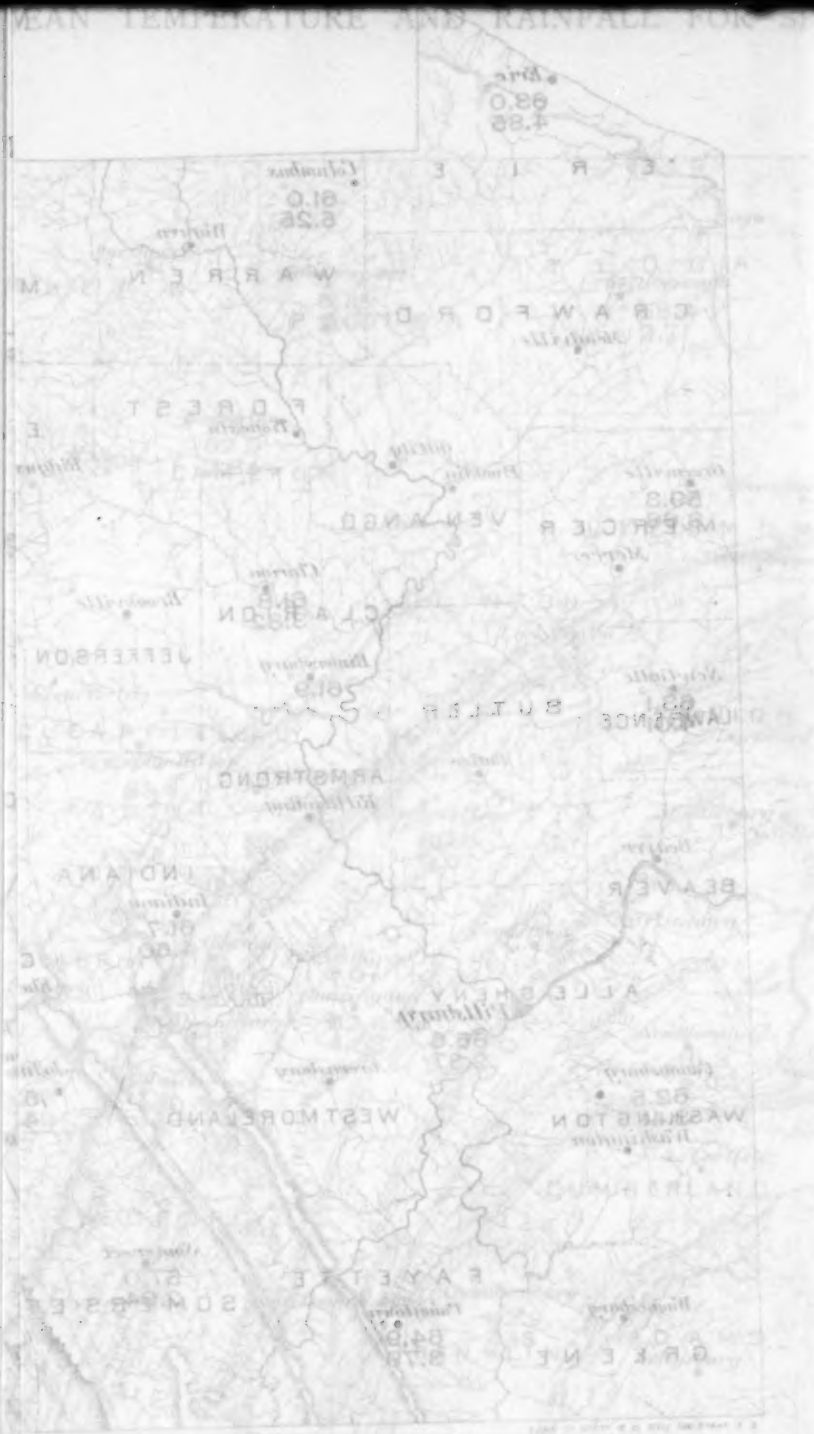
ISOTHERMAL LINES,

SHOWING THE

NORMAL TEMPERATURE OF PENNSYLVANIA FOR S



A FOR SEPTEMBER.



PENNSYLVANIA STATE WEATHER SERVICE.

MONTHLY WEATHER REVIEW

FOR OCTOBER, 1889.

Prepared under the Direction of the Committee on Meteorology of the FRANKLIN INSTITUTE.

HALL OF THE FRANKLIN INSTITUTE,

PHILADELPHIA, October 31, 1889.

TEMPERATURE.

The mean temperature of fifty-nine stations for October, 1889, was 47°·2, which is about 4° below the average, and 1° above the month of October, 1888. The means of the daily maximum and minimum temperatures, were 57°·3, and 37°·3, respectively. These give a mean temperature of 47°·3 and an average daily range of 20°·0. The stations that recorded the highest temperatures during the month were Coatesville, 83°; Annville, 82°; West Chester, 80°; Lancaster, 80°, and Westtown, 80°. These occurred on the 12th.

The lowest were Wellsboro, 13°; Dyberry, 14°; Columbus, 14°, and Phillipsburg, 14°. These occurred on the 24th, and are 3° below the coldest temperatures generally reached in October.

Total deficiency in temperature during October, at Pittsburgh, 103°.

Total deficiency in temperature during October, at Philadelphia, 110°.

Total excess in temperature since January 1st, at Pittsburgh, 90°.

Total excess in temperature since January 1st, at Philadelphia, 222°.

BAROMETER.

The mean barometer for the month, 30·08, is slightly above the average. The highest pressure occurred on the 23d, and the lowest on the 1st and 27th.

The extreme range was about nine-tenths [·9].

PRECIPITATION.

The average rainfall for the month was 3·85 inches, which is nearly normal. There was a small excess in the eastern portion of the State, and a small deficiency in the western.

The largest totals in inches were Eagles Mere, 8·61; Reading, 5·74; Drifton, 5·74; Wellsboro, 5·61; Westtown, 5·73; Swarthmore, 5·29, and Quakertown, 5·23.

General rain-storms took place on the 1st, 6th, 12th, 13th, 14th, 22d, 23d, 26th, 27th, 28th and 31st.

The heaviest rainfall during the month was on the 27th.

There was a heavy hail-storm in several sections on the 1st, and the first general snow occurred on the 23d. The quantity that fell was small and soon melted.

Total deficiency in precipitation during the month, at Pittsburgh, 0·50 inches.

Total excess in precipitation during the month, at Philadelphia, 0·93 inches.

Total excess in precipitation since January 1st, at Pittsburgh, 3·00 inches.

Total excess in precipitation since January 1st, at Philadelphia, 8·81 inches.

WIND AND WEATHER.

No severe gales passed over the State during the month. The weather was cold and wet.

Average Number.—Rainy days, 10; clear days, 8; fair days, 9; cloudy days, 14.

Prevailing Direction of Wind.—Northwest.

MISCELLANEOUS PHENOMENA.

Thunder-storms.—Charlesville, 11th; Reading, 12th; Blue Knob, 12th; Le Roy, 1st, 27th; Quakertown, 1st, 12th; Johnstown, 12th; Emporium, 1st, 12th; State College, 1st; West Chester, 1st, 12th; Rimersburg, 12th; Grampian Hills, 12th; Catawissa, 1st, 12th, 27th; Carlisle, 12th; Swarthmore, 1st; Uniontown, 31st; Huntingdon, 1st; Petersburg, 1st; Indiana, 12th; Lancaster, 1st; Myerstown, 1st, 12th; Annville, 1st, 27th; Wilkes-Barre, 1st; New Bloomfield, 12th; Philadelphia, 1st, 12th; Girardville, 1st, 12th; Selins Grove, 1st, 12th, 13th, 27th; Eagles Mere, 1st; Wellsboro, 1st, 27th; Columbus, 1st, 3d, 13th; Canonsburg, 31st; Dyberry, 1st, 12th; South Eaton, 1st; Gettysburg, 12th; Centre Valley, 1st, 12th.

Hail.—Blue Knob, 18th; Emporium, 1st; State College, 1st; Catawissa, 1st; Philadelphia, 1st; Girardville, 15th; South Eaton, 1st; Centre Valley, 12th.

Snow.—Charlesville, 23d; Reading, 23d; Blue Knob, 6th, 23d; Hollidaysburg, 23d; Le Roy, 7th, 23d; Forks of Neshaminy, 23d; Quakertown, 23d; Johnstown, 7th, 23d; Emporium 7th; State College, 8th, 23d; Phillipsburg, 22d; West Chester, 23d; Coatesville, 1st; Kennett Square, 23d; Rimersburg, 7th; Grampian Hills, 23d; Carlisle, 23d; Harrisburg, 23d; Swarthmore, 23d; Chambersburg, 23d; McConnellsburg, 23d; Huntingdon, 23d; Petersburg, 23d; Indiana, 7th, 23d; Lancaster, 23d; Myerstown, 23d; Annville, 23d; Drifton, 23d; Wilkes-Barre, 23d; Greenville, 7th; Pottstown, 23d; New Bloomfield, 23d; Philadelphia, 23d; Girardville, 22d; Selins Grove, 7th, 23d; Eagles Mere, 7th, 22d; Wellsboro, 7th, 14th, 22d; Dyberry, 23d; Honesdale, 22d; York, 23d; Gettysburg, 23d; Centre Valley, 23d; Westtown, 23d; Nisbet, 23d.

Frost.—Pittsburgh, 15th, 16th, 19th, 21st, 23d, 24th; Charlesville, 3d, 5th,

Monthly Summary of Reports by Voluntary Observers of the Pennsylvania State Weather Se

County.	Station.	Elevation above Sea Level (feet).	Barometer.			Temperature.													Relative Humidity.	Dew Point.	Precipi	
							Maximum.		Minimum.				Daily Range.									
			Mean.	Highest.	Lowest.	Mean.	Highest.	Date.	Lowest.	Date.	Mean of Maximum.	Mean of Minimum.	Mean.	Greatest.	Date.	Least.	Date.			Total Inches.	Total Snowfall During Month.
[1]	Gettysburg (24 days),	624	. .	. . .	. . .	49·7	79·0	12	26·0	24	58·4	40·4	18·0	44·0	12	4·0	24	. . .	. . .	4·16	1·50
ney,[1]	Pittsburgh,	847	30·088	30·392	29·707	51·0	75·0	11	30·0	24	52·3	42·7	16·6	33·0	19	2·0	13	75·8	41·3	2·06	. . .
rd,	Charlesville,	1,300	. . .	. . .	. . .	47·2	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	79·2	41·6	. . .	. . .
]	Reading,	304	30·051	30·405	29·664	49·8	75·0	1	27·0	22	60·3	39·3	21·0	36·0	17	6·0	31	90·6	47·0	5·74	. . .
[1]	Altoona,	1,181	. . .	. . .	. . .	51·4	71·0	2, 11	26·0	24	59·9	42·6	17·3	29·0	13	6·0	27	65·4	39·1	2·38	. . .
	Blue Knob,	2,100	. . .	. . .	. . .	44·8	70·0	11	22·0	24	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4·30	3·60
	Hollidaysburg,	947	. . .	. . .	. . .	41·0	76·0	11	17·0	24	60·0	35·0	25·0	44·0	19	9·0	29	83·0	35·5	2·90	. . .
rd,	Wysox,	718	30·074	30·488	29·624	43·7	70·5	1	16·0	24	53·9	34·4	19·5	39·0	19	3·5	13	82·7	38·6	3·16	. . .
rd,	Le Roy,	1,400	. . .	. . .	. . .	42·7	66·0	12	20·0	24	49·8	36·7	13·1	30·0	19	2·0	30	. . .	. . .	4·73	1·90
,	Forks of Neshaminy,		. . .	. . .	. . .	49·8	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4·77	. . .
,	Quakertown,	536	30·050	30·390	29·560	47·4	77·5	12	26·5	25	59·4	37·4	22·0	37·0	12	8·5	31	80·0	40·9	5·83	. . .
ia,	Johnstown,	1,184	30·076	30·370	29·723	47·1	73·0	3, 11	21·0	24	58·8	37·5	21·3	38·0	19	5·0	29	. . .	. . .	2·55	1·00
on,	Emporium,	1,030	. . .	. . .	. . .	46·3	69·0	11	15·0	24	56·8	33·9	22·9	45·0	19	9·0	31	. . .	. . .	3·70	. . .
n,[1]	Mauch Chunk (19 days),	550	. . .	. . .	. . .	46·8	74·5	20	24·0	24	56·3	37·3	19·0	37·5	17	4·5	31	. . .	. . .	4·95	. . .
,	State College—																				
	Agricultural Experiment Station,	1,191	30·032	30·404	29·507	46·0	72·0	11	20·0	24	54·6	37·3	17·3	31·0	19	4·0	30	75·3	38·0	3·36	. . .
,	Phillipsburg,	1,350	. . .	. . .	. . .	44·0	75·0	11	14·0	24	56·1	33·0	23·1	45·0	11	7·0	27	. . .	. . .	3·54	. . .
,	West Chester,	455	30·028	30·372	29·541	49·9	80·0	12	28·0	24	59·6	41·7	17·9	29·5	17	7·0	29	71·0	41·2	4·97	. . .
,	Coatesville,	380	. . .	. . .	. . .	48·3	83·0	12	29·0	22, 24	61·2	38·7	22·5	41·0	11	8·0	30	. . .	. . .	4·61	1·00
,	Kennett Square,	275	. . .	. . .	. . .	50·0	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5·04	. . .
,[1]	Westtown,	350	. . .	. . .	. . .	49·4	80·0	12	26·5	24	60·8	38·0	22·8	42·0	11	13·5	14	. . .	. . .	5·37	·50
n,	Rimersburg,	1,500	. . .	. . .	. . .	46·0	71·0	11	23·0	24	52·0	39·0	13·0	25·0	24	2·0	28	. . .	. . .	. . .	. . .
n,	Clarion—																				
	State Normal School,	1,530	. . .	. . .	. . .	45·8	71·5	11	19·0	24	55·3	35·6	19·7	38·0	11	1·0	30	78·3	39·0	2·17	. . .
ield,	Grampian Hills,	1,450	. . .	. . .	. . .	45·0	70·0	11	20·0	26	50·9	38·1	12·8	36·0	5	2·0	13	. . .	. . .	3·21	. . .
n,	Lock Haven,	560	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
hia,	Catawissa,	491	. . .	. . .	. . .	48·0	70·0	1	25·0	24	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2·82	. . .
rd,	Meadville—																				
	Allegheny College,	1,050	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
erland,	Carlisle,	480	. . .	. . .	. . .	50·1	78·0	11	22·5	24	61·9	41·9	20·0	36·0	17	4·5	30	82·7	41·9	3·75	. . .
hia,[1]	Harrisburg,	361	30·080	30·431	29·526	50·1	76·0	11	29·0	24	57·8	42·5	15·3	34·0	11	3·0	28	79·6	42·2	3·33	. . .
ware,	Swarthmore—																				
	Swarthmore College,	190	30·027	30·355	29·641	50·1	79·3	12	32·0	24	59·7	41·3	18·4	41·3	12	7·9	29	77·0	42·6	5·29	. . .
	Erie,	681	30·090	30·480	29·580	46·0	69·0	3	30·0	24	52·0	40·0	12·0	27·0	3	3·0	28	75·0	38·0	3·37	. . .
ne,	Uniontown,	1,000	30·008	30·258	29·684	50·1	75·0	5	25·0	24	58·3	41·2	17·1	38·0	5	3·0	28	79·0	44·0	3·31	. . .
st,	Tionesta,	1,057	. .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
lin,[1]	Chambersburg—																				
	Wilson Female College,	618	30·110	30·394	29·763	47·9	78·0	11	23·0	24	58·1	37·1	21·0	40·0	17	8·0	29	82·4	43·4	3·24	. . .
n,	McConnellsburg,	875	. . .	. . .	. . .	48·2	77·0	11, 12	26·0	9	60·4	37·7	22·7	42·0	11	7·0	30	76·9	41·0	3·14	·50
ngdon,[1]	Huntingdon—																				
	The Normal College,	650	. . .	. . .	. . .	46·5	76·0	11	18·0	24	60·4	36·2	24·2	43·0	11	5·0	30	. . .	. . .	3·67	1·00
ngdon,	Petersburg,	700	. . .	. . .	. . .	46·5	76·0	11, 20	20·0	24	57·1	38·3	18·8	40·0	20	4·0	7	. . .	. . .	3·34	·50
n,	Indiana—																				
	State Normal School,	1,350	. . .	. . .	. . .	47·1	72·6	11	21·3	24	60·0	31·0	29·0	39·6	14	10·0	30	79·2	43·7	3·52	. . .
ster,	Lancaster,	411	30·062	30·364	29·627	49·7	80·0	12	27·0	24	59·5	39·3	20·2	37·0	11	6·0	30	89·0	46·9	3·88	. . .
nce,	New Castle,	932	. . .	. . .	. . .	48·0	73·0	11	17·0	24	56·7	35·0	21·7	43·0	19	6·0	30	. . .	. . .	1·88	. . .
on,	Myerstown,	474	30·018	30·342	29·585	47·8	76·0	12	26·8	24	63·3	38·5	24·8	34·0	11	5·9	30	84·9	43·6	4·47	. . .
on,	Annville—																				
	Lebanon Valley College,	339	. . .	. . .	. . .	53·6	82·0	12	32·0	24	. . .	. . .	. . .	. . .	. . .	. . .	. . .	78·1	46·2	. . .	. . .
h,	Centre Valley,	348	. . .	. . .	. . .	53·5	82·0	12	30·0	24	65·0	42·0	25·0	42·0	19	4·0	28	. . .	. . .	3·09	. . .
ne,	Drifton—																				
	Drifton Hospital,	1,655	. . .	. . .	. . .	45·0	68·0	1	26·0	24	55·1	36·5	18·6	30·0	3	9·0	13	. . .	. . .	5·74	. . .
ne,[1]	Wilkes-Barre	575	. . .	. . .	. . .	49·0	75·0	15	23·0	24	59·0	39·0	20·0	37·0	19	5·0	30	. . .	. . .	3·16	. . .
ming,[1]	Nisbet,	550	. . .	. . .	. . .	45·1	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4·20	. . .
r,[1]	Greenville—																				
	Thiel College,	1,000	30·001	30·347	29·598	42·2	74·0	11	19·3	24	55·6	35·6	20·0	38·3	19	5·0	30	94·1	40·7	2·74	. . .
omery,	Pottstown,	150	. .	. . .	. . .	51·0	79·0	12	30·0	24	59·0	43·0	16·0	31·0	17	5·0	14	76·0	43·8	4·56	. . .
mpton,	Bethlehem,	360	. . .	. . .	. . .	51·0	73·0	1	28·0	24	59·0	40·0	19·0	33·0	17	4·0	6	73·0	44·0	3·29	. . .
	New Bloomfield,	400	. . .	. . .	. . .	47·4	75·0	12, 20	20·0	24	58·7	36·3	22·4	39·0	17	6·0	31	. . .	. . .	4·35	1·00
delphia,[1]	Philadelphia,	117	30·056	30·400	29·560	52·8	79·0	12	32·0	23	60·1	45·4	14·7	26·0	12	4·0	13	72·0	42·0	3·76	. . .
	Coudersport,	1,670	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
kill,	Girardville,	1,000	30·082	30·424	29·679	46·5	70·0	1, 12	25·0	24	56·3	38·0	18·3	30·0	11	7·0	31	. . .	. . .	4·41	. . .
r,	Selins Grove,	445	. . .	. . .	. . .	48·9	69·0	20	22·0	24	61·4	32·4	29·0	47·0	11	10·0	30	74·8	41·0	3·65	. . .
set,	Somerset,	2,250	. . .	. . .	. . .	44·6	73·0	12	17·0	24	57·1	34·2	22·9	38·0	20	9·0	7	87·9	39·9	2·61	. . .
an,	Eagles Mere,	2,060	30·119	30·520	29·643	41·7	66·0	27	18·0	24	47·5	34·7	12·8	24·0	24	3·0	29	80·2	35·0	8·61	·50
	Wellsboro,	1,327	30·050	30·444	29·540	40·9	65·0	19	13·0	24	50·8	31·8	19·0	34·0	24	2·0	30	73·2	32·4	5·61	. . .
,[1]	Lewisburg,	450	. . .	. . .	. . .	44·2	67·0	20	20·0	24	54·1	34·2	19·9	41·0	21	10·0	13	. . .	. . .	3·04	. . .
n,	Columbus,	1,410	. . .	. . .	. . .	43·0	68·0	16	14·0	24	52·3	33·7	18·6	42·0	16	2·0	28	. . .	. . .	3·44	. . .
ington,	Canonsburg,	950	. . .	. . .	. . .	45·0	74·0	11, 12	23·0	24	60·0	35·5	24·5	40·0	11	6·0	30	80·4	33·6	2·87	. . .
e,	Dyberry,	1,100	. . .	. . .	. . .	41·7	70·0	12	14·0	24	53·7	32·9	20·8	42·0	19	3·0	29	. . .	. . .	4·03	. . .
e,	Honesdale,	1,000	. . .	. . .	. . .	45·4	68·0	12	18·0	24	54·0	36·7	17·3	36·0	19	4·0	29	63·3	41·3	4·02	. . .
ning,[1]	South Eaton	660	. . .	. . .	. . .	43·0	70·0	1	20·5	24	54·7	35·3	19·4	27·5	24	4·0	29	. . .	. . .	4·11	. . .
[1]	York,	385	30·049	30·402	29·744	49·9	80·0	12	27·5	24	62·1	39·3	22·8	38·0	12	6·0	30	76·7	42·0	4·03	. . .

[1] Observations taken at 8 A. M. and 8 P. M. [2] Observations taken at 12 Noon.

Temperature.									Relative Humidity.	Dew Point.	Precipitat		
Minimum.		Mean of Maximum.	Mean of Minimum.	Daily Range.									
Lowest.	Date.			Mean.	Greatest.	Date.	Least.	Date.			Total Inches.	Total Snowfall During Month.	Depth of Snow on Ground at
26·0	24	58·4	40·4	18·0	44·0	12	4·0	24	. . .	. . .	4·16	1·50	. . .
30·0	24	59·3	42·7	16·6	33·0	19	2·0	13	75·8	41·3	2·06	. . .	. . .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	79·2	41·6	. . .	. . .	. . .
27·0	22	60·3	39·3	21·0	36·0	17	6·0	31	90·6	47·0	5·74	. . .	. . .
26·0	24	59·9	42·6	17·3	29·0	13	6·0	27	65·4	39·1	2·38	. . .	. . .
22·0	24	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4·30	3·60	. . .
17·0	24	60·0	35·0	25·0	44·0	19	9·0	29	83·0	35·5	2·90	. . .	. . .
16·0	24	53·9	34·4	19·5	39·0	19	3·5	13	82·7	38·6	3·16	. . .	. . .
20·0	24	49·8	36·7	13·1	30·0	19	2·0	30	. . .	. . .	4·73	1·90	. . .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4·77	. . .	. . .
26·5	25	59·4	37·4	22·0	37·0	12	8·5	31	80·0	40·9	5·23	. . .	. . .
21·0	24	58·8	37·5	21·3	38·0	19	5·0	29	. . .	. . .	2·55	1·00	. . .
15·0	24	56·8	33·9	22·9	45·0	19	9·0	31	. . .	. . .	3·70	. . .	. . .
24·0	24	56·3	37·3	19·0	37·5	17	4·5	31	. . .	. . .	4·95	. . .	. . .
20·0	24	54·6	37·3	17·3	31·0	19	4·0	30	75·3	38·0	3·36	. . .	. . .
14·0	24	56·1	33·0	23·1	45·0	11	7·0	27	. . .	. . .	3·54	. . .	. . .
28·0	24	59·6	41·7	17·9	29·5	17	7·0	29	71·0	41·2	4·97	. . .	. . .
29·0	22, 24	61·2	38·7	22·5	41·0	11	8·0	30	. . .	. . .	4·61	1·00	. . .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5·04	. . .	. . .
26·5	24	60·8	38·0	22·8	42·0	11	13·5	14	. . .	. . .	5·37	·30	. . .
23·0	24	52·0	39·0	13·0	25·0	24	2·0	28	. . .	. . .	. . .	. . .	. . .
19·0	24	55·3	35·6	19·7	38·0	11	1·0	30	78·3	39·0	2·17	. . .	. . .
20·0	26	50·9	38·1	12·8	36·0	5	2·0	13	. . .	. . .	3·21	. . .	. . .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
25·0	24	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2·82	. . .	. . .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
22·5	24	61·9	41·9	20·0	36·0	17	4·5	30	82·7	41·9	3·75	. . .	. . .
29·0	24	57·8	42·5	15·3	34·0	11	3·0	28	79·6	42·2	3·33	. . .	. . .
32·0	24	59·7	41·3	18·4	41·3	12	7·9	29	77·0	42·6	5·29	. . .	. . .
30·0	24	52·0	40·0	12·0	27·0	3	3·0	28	75·0	38·0	3·37	. . .	. . .
25·0	24	58·3	41·2	17·1	38·0	5	3·0	28	79·0	44·0	3·31	. . .	. . .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .	. . .	. . .	. . .	. . .	. . .	. . .
23·0	24	58·1	37·1	21·0	40·0	17	8·0	29	82·4	43·4	3·24	. . .	. . .
26·0	9	60·4	37·7	22·7	42·0	11	7·0	30	76·9	41·0	3·14	·50	. . .
18·0	24	60·4	36·2	24·2	43·0	11	5·0	30	. . .	. . .	3·67	1·00	. . .
20·0	24	57·1	38·3	18·8	40·0	20	4·0	7	. . .	. . .	3·34	·50	. . .
21·3	24	60·0	31·0	29·0	39·6	14	10·0	30	79·2	43·7	3·52	. . .	. . .
27·0	24	59·5	39·3	20·2	37·0	11	6·0	30	89·0	46·9	3·88	. . .	. . .
17·0	24	56·7	35·0	21·7	43·0	19	6·0	30	. . .	. . .	1·88	. . .	. . .
26·8	24	63·3	38·5	24·8	34·0	11	5·9	30	84·9	43·6	4·47	. . .	. . .
32·0	24	. . .	. . .	. . .	. . .	. . .	. . .	. . .	78·1	46·2	. . .	. . .	. . .
30·0	24	65·0	43·0	25·0	42·0	19	4·0	28	. . .	. . .	3·09	. . .	. . .
26·0	24	55·1	36·5	18·6	30·0	3	9·0	13	. . .	. . .	5·74	. . .	. . .
23·0	24	59·0	39·0	20·0	37·0	19	5·0	30	. . .	. . .	3·16	. . .	. . .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4·20	. . .	. . .
19·3	24	55·6	35·6	20·0	38·3	19	5·0	30	94·1	40·7	2·74	. . .	. . .
30·0	24	59·0	43·0	16·0	31·0	17	5·0	14	76·0	43·8	4·56	. . .	. . .
28·0	24	59·0	40·0	19·0	33·0	17	4·0	6	73·0	44·0	3·29	. . .	. . .
20·0	24	58·7	36·3	22·4	39·0	17	6·0	31	. . .	. . .	4·35	1·00	. . .
32·0	23	60·1	45·4	14·7	26·0	12	4·0	13	72·0	42·0	3·76	. . .	. . .
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
25·0	24	56·3	38·0	18·3	30·0	11	7·0	31	. . .	. . .	4·41	. . .	. . .
22·0	24	61·4	32·4	29·0	47·0	11	10·0	30	74·8	41·0	3·65	. . .	. . .
17·0	24	57·1	34·2	22·9	38·0	20	9·0	7	87·9	39·9	2·61	. . .	. . .
18·0	24	47·5	34·7	12·8	24·0	24	3·0	29	80·2	35·0	8·61	·50	. . .
13·0	24	50·8	31·8	19·0	34·0	24	2·0	30	73·2	32·4	5·61	. . .	. . .
20·0	24	54·1	34·2	19·9	41·0	21	10 0	13	. . .	. . .	3·04	. . .	. . .
14·0	24	52·3	33·7	18·6	42·0	16	2·0	28	. . .	. . .	3·44	. . .	. . .
23·0	24	60·0	35·5	24·5	40·0	11	6·0	30	80·4	33·6	2·87	. . .	. . .
14·0	24	53·7	32·9	20·8	42·0	19	3·0	29	. . .	. . .	4·03	. . .	. . .
18·0	24	54·0	36·7	17·3	36·0	19	4·0	29	63·3	41·3	4·02	. . .	. . .
20·5	24	54·7	35·3	19·4	27·5	24	4·0	29	. . .	. . .	4·11	. . .	. . .
27·5	24	62·1	39·3	22·8	38·0	12	6·0	30	76·7	42·0	4·03	. . .	. . .

Precipitation.			Number of Days.			Wind.			Observers.
Total Snowfall During Month.	Depth of Snow on Ground at End of Month.	Number of Days Rainfall.	Clear.	Fair.	Cloudy.	Prevailing Direction. 7 A. M.	2 P. M.	9 P. M.	
1'50	. . .	10	7	9	22	NE	. . .	SE	Prof. E. S. Breidenbaugh.
. . .	. . .	14	7	10	14	N	N	N	Oscar D. Stewart, Sgt. Sig. Corps
. . .	. . .	. . .	6	17	8	W	N	NW	Rev. A. Thos. G. Apple.
. . .	. . .	11	7	11	13	NW	NW	NW	C. M. Dechant, C.E.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Dr. Charles B. Dudley.
3'60	. . .	12	4	13	14	NW	NW	NW	A. H. Boyle.
. . .	. . .	10	12	9	10	NW	W	W	Prof. J. A. Stewart.
. . .	. . .	9	10	2	19	NW	NW	NW	Charles Beecher.
1'90	. . .	13	8	6	17	W	SW	N	Geo. W. T. Warburton.
. . .	. . .	11	8	8	15	NW	NW	NW	J. C. Hilsman.
. . .	. . .	17	4	15	12	NE	NE	N	J. L. Heacock.
1'00	. . .	13	8	13	10	NW	NW	NW	E. C. Lorentz.
. . .	. . .	7	9	8	14	W	N	NW	T. B. Lloyd
. . .	. . .	8	. . .	. . .	. . .	. . .	. . .	. . .	John J. Boyd.
. . .	. . .	12	4	15	12	W	W	W	Prof. Wm. Frear.
. . .	. . .	10	9	6	16	SW	SW	SW	Geo. H. Dunkle.
. . .	. . .	14	13	4	14	N	NW	NW	Jesse C. Green, D.D.S.
1'00	. . .	13	10	9	12	W	W	W	W. T. Gordon.
. . .	. . .	11	13	7	11	N	N	N	Benj. P. Kirk.
'50	. . .	11	9	8	14	W	W	W	Prof. Wm. F. Wickersham.
. . .	. . .	9	6	12	13	NW	NW	W	Rev. W. W. Deatrick, A.M.
. . .	. . .	2	9	8	14	SW	NW	SW	C. M. Thomas, B.S.
. . .	. . .	9	8	10	13	W	W	W	Nathan Moore.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	Prof. John A. Robb.
. . .	. . .	9	. . .	. . .	. . .	. . .	. . .	. . .	Robert M. Graham.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	R. B. Derickson.
. . .	. . .	9	7	12	12	W	N	N	J. E. Pague.
. . .	. . .	13	7	11	13	N	N	N	Frank Ridgway, Sgt. Sig. Corps.
. . .	. . .	7	1	9	21	NW	NW	NW	Prof. Susan J. Cunningham.
. . .	. . .	12	7	9	15	SW	SW	SW	Peter Wood, Sgt. Sig. Corps.
. . .	. . .	10	12	14	5	NW	NW	NW	Wm. Hunt.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	R. L. Haslet.
. . .	. . .	5	8	9	14	. . .	. . .	. . .	Miss Mary A. Ricker.
'50	. . .	6	11	9	11	W	W	W	Thomas F. Sloan.
1'00	. . .	11	13	9	9	W	W	W	Prof. W. J. Swigart.
'30	. . .	9	2	17	12	W	W	W	J. E. Rooney.
. . .	. . .	11	5	11	15	NW	N	NW	Prof. S. C. Schmucker.
. . .	. . .	13	6	14	11	W	W	W	E. E. Weller.
. . .	. . .	5	6	9	16	W	W	W	Wm. T. Butz.
. . .	. . .	14	6	6	19	NW	NW	NW	Wm. H. Kline.
. . .	. . .	. . .	7	11	13	W	W	W	Geo. W. Bowman, A.M., Ph.D.
. . .	. . .	13	3	18	10	N	NW	NW	H. W. Mullen.
. . .	. . .	9	. . .	. . .	. . .	NW	NW	NW	H. D. Miller, M.D.
. . .	. . .	9	11	4	16	NE	NE	NE	A. W. Betterly.
. . .	. . .	9	. . .	. . .	. . .	. . .	. . .	. . .	John S. Gibson, P. M.
. . .	. . .	10	7	6	18	NE	NE	NE	Prof. S. H. Miller.
. . .	. . .	11	9	8	14	NW	NW	NE	Charles Moore, D.D.S.
. . .	. . .	8	17	2	12	W	W	SE	Lerch & Rice.
1'00	. . .	9	8	8	15	W	W	W	Frank Mortimer.
. . .	. . .	13	10	7	14	NW	NW	NW	Luther M. Dey, Sgt. Sig. Corps.
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	C. L. Peck.
. . .	. . .	12	10	9	12	NW	NW	NW	E. C. Wagner.
. . .	. . .	12	4	15	12	NW	NW	NW	J. M. Boyer,
. . .	. . .	10	9	11	11	NW	NW	NW	W. M. Schrock.
'50	. . .	12	6	11	14	NW	SW	SW	E. S. Chase.
. . .	. . .	14	6	10	15	N	N	N	H. D. Deming.
. . .	. . .	6	8	10	13	NE	NE	NE	F. O. Whitman.
. . .	. . .	12	8	5	18	N	N	N	Wm. Loveland.
. . .	. . .	16	13	10	8	SW	SE	SE	A. L. Runion.
. . .	. . .	11	3	13	13	W	NW	NW	Theodore Day.
. . .	. . .	9	. . .	. . .	. . .	. . .	. . .	. . .	John Torrey.
. . .	. . .	12	9	5	17	N	N	N	Benj. M. Hall.
. . .	. . .	9	12	9	10	NW	NW	NW	Mrs. L. H. Grenewald.

T. F. Townsend, *Sergeant Signal Corps, Assistant.*

8th, 15th, 16th, 19th, 22d, 24th; Reading, 9th, 16th, 17th, 22d; Blue Knob, 3d, 18th, 19th; Hollidaysburg, 9th, 15th, 24th; Wysox, 3d, 5th, 8th, 9th, 10th, 11th, 15th, 16th, 17th, 18th, 19th, 22d, 23d, 24th, 25th; Le Roy, 3d, 5th, 7th, 9th, 16th, 19th, 20th, 21st, 22d, 23d, 24th, 25th; Forks of Neshaminy, 8th, 9th, 17th, 22d; Quakertown, 3d, 5th, 9th, 17th, 19th, 22d, 24th, 25th; Johnstown, 3d, 5th, 9th, 16th, 17th, 19th, 22d, 24th, 25th; Emporium, 9th, 15th, 16th, 17th, 19th, 21st, 22d, 24th; State College, 3d, 5th, 9th, 15th, 16th, 19th, 22d; Phillipsburg, 3d, 9th, 15th, 16th, 19th, 22d, 24th; West Chester, 3d, 9th; Coatesville, 3d, 5th, 8th, 9th, 11th, 17th, 18th, 19th, 22d; Kennett Square, 9th; Rimersburg, 5th, 15th, 16th, 21st, 23d, 24th; Grampian Hills, 3d, 5th, 9th, 15th, 19th; Catawissa, 3d, 5th, 9th, 16th, 17th, 19th, 22d, 24th, 25th; Carlisle, 5th, 6th, 9th, 18th, 22d; Harrisburg, 23d, 24th; Erie, 16th, 18th, 21st; Uniontown, 3d, 15th, 16th, 19th; Chambersburg, 3d, 4th, 5th, 9th, 16th, 17th, 18th, 19th; McConnellsburg, 3d, 5th, 9th, 24th; Huntingdon, 9th, 16th, 17th, 19th, 22d, 24th; Petersburg, 5th, 6th, 19th, 22d, 24th; Lancaster, 3d, 4th, 5th, 9th, 17th, 19th, 22d, 24th; New Castle, 9th, 15th, 19th, 24th; Myerstown, 3d, 5th, 7th, 9th, 17th, 19th, 22d, 24th; Annville, 3d, 19th, 22d, 24th; Wilkes Barre, 22d, 23d; Greenville, 9th, 15th, 16th, 19th, 21st, 22d, 23d, 24th; Bethlehem, 3d, 5th, 17th, 19th, 22d, 24th; New Bloomfield, 5th, 7th, 16th, 17th, 19th, 21st, 24th, 25th; Philadelphia, 2d, 5th, 9th, 17th, 22d; Girardville, 1st, 2d, 3d, 4th, 5th, 7th, 8th, 9th, 11th, 16th, 17th, 18th, 19th, 21st, 22d, 24th; Selins Grove, 3d, 4th, 5th, 6th, 9th, 11th, 16th, 17th, 18th, 22d, 24th, 25th; Somerset, 3d, 4th, 5th, 9th, 15th, 16th, 17th, 18th, 19th, 22d, 25th; Eagles Mere, 3d, 4th, 5th, 9th, 15th, 18th, 19th, 23d, 24th; Wellsboro, 3d, 5th, 7th, 9th, 15th, 16th, 17th, 19th, 22d, 23d, 24th; Columbus, 3d, 5th, 9th, 11th, 12th, 16th, 18th, 19th, 21st, 22d, 23d, 24th, 25th; Dyberry, 3d, 5th, 8th, 11th, 16th, 17th, 18th, 19th, 21st, 22d, 23d, 24th, 25th; Honesdale, 9th, 24th; South Eaton, 16th, 17th, 18th, 19th; York, 17th, 19th, 22d, 24th; Gettysburg, 3d, 5th, 9th, 11th, 12th, 14th, 23d, 24th, 25th, 26th, 31st; Centre Valley, 2d; Mauch Chunk, 17th, 19th; Westtown, 3d, 9th, 16th, 17th, 22d; Nisbet, 24th.

Sleet.—Blue Knob, 8th, 29th, 30th; New Bloomfield, 14th; Wellsboro, 22d.

Coronæ.—Charlesville, 5th; Reading, 6th; Greenville, 4th, 9th.

Solar Halos.—Le Roy, 3d; Philadelphia, 19th; Eagles Mere, 3d, 12th; Wellsboro, 3d.

Lunar Halos.—Le Roy, 2d; State College, 2d, 8th; West Chester, 4th; Catawissa, 8th; Petersburg, 2d; Dyberry, 8th.

Meteors.—Eagles Mere, 18th.

WEATHER FORECASTS.

Percentage of local verifications of weather and temperature signals as reported by displaymen for October, 1889:

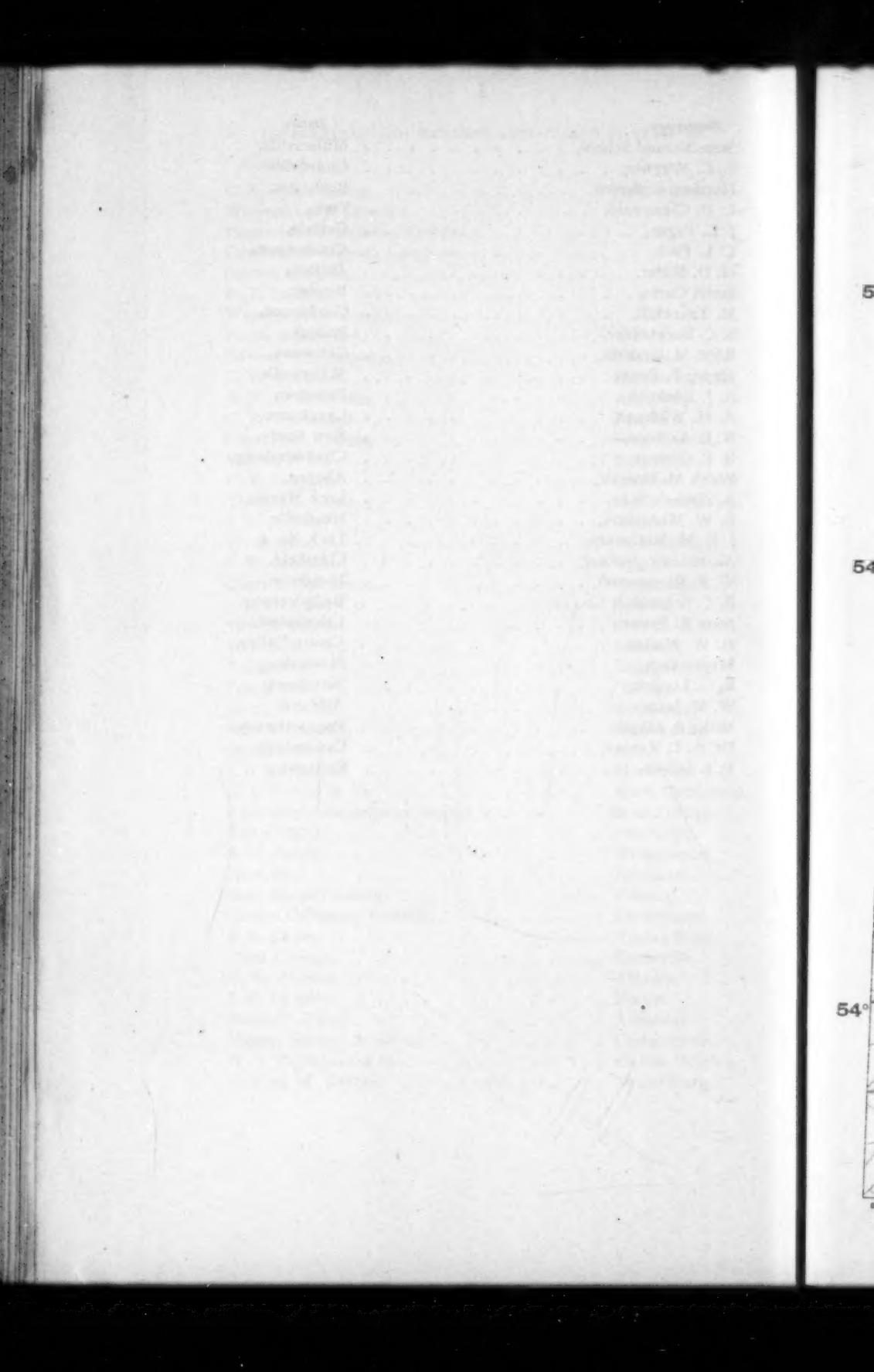
Weather, 87 per cent.

Temperature, 90 per cent.

TEMPERATURE AND WEATHER SIGNAL DISPLAY STATIONS.

Displayman.	*Station.*
U. S. Signal Office,	Philadelphia.
Wanamaker & Brown,	"
Pennsylvania Railroad Company,	"
Continental Brewing Company,	"
Samuel Simpson,	"
B. T. Babbitt,	"
Western Meat Company,	"
Neptune Laundry,	"
Chester Oil Company,	Chester.
C. W. Burkhart,	Shoemakerville.
A. N. Lindenmuth,	Allentown.
C. B. Whitehead,	Bradford.
Capt. Geo. R. Guss,	West Chester.
Werner & Son,	Emporium.
C. E. Lenhart,	Latrobe.
Thomas F. Sloan,	McConnellsburg.
J. H. Fulmer,	Muncy.
W. T. Butz,	New Castle.
S. W. Morrison,	Oxford.
Capt. A. Goldsmith,	Quakertown.
J. L. Morrison,	Sharon.
Wm. A. Engel,	Shenandoah.
Wm. Schrock,	Somerset.
Postmaster,	Meadville.
Frank Ross,	Oil City.
Lerch & Rice,	Bethlehem.
John W. Aitken,	Carbondale.
Signal Office,	Erie.
J. R. Raynsford,	Montrose.
E. P. Wilbur & Co.,	South Bethlehem.
Agricultural Experiment Station,	State College.
Signal Office,	Pittsburgh.
E. H. Baker,	Williamsport.
New Era,	Lancaster.
State Normal School,	Clarion.
Clarion Collegiate Institute,	Rimersburg.
E. S. Chase,	Eagles Mere.
Thiel College,	Greenville.
D. G. Hurley,	Altoona.
J. E. Forsythe,	Butler.
James H. Fones,	Tionesta.
Wister, Hacker & Savage,	Germantown.
W. J. Thompson & Co.,	Clifton Heights.
Steward M. Dreher,	Stroudsburg.

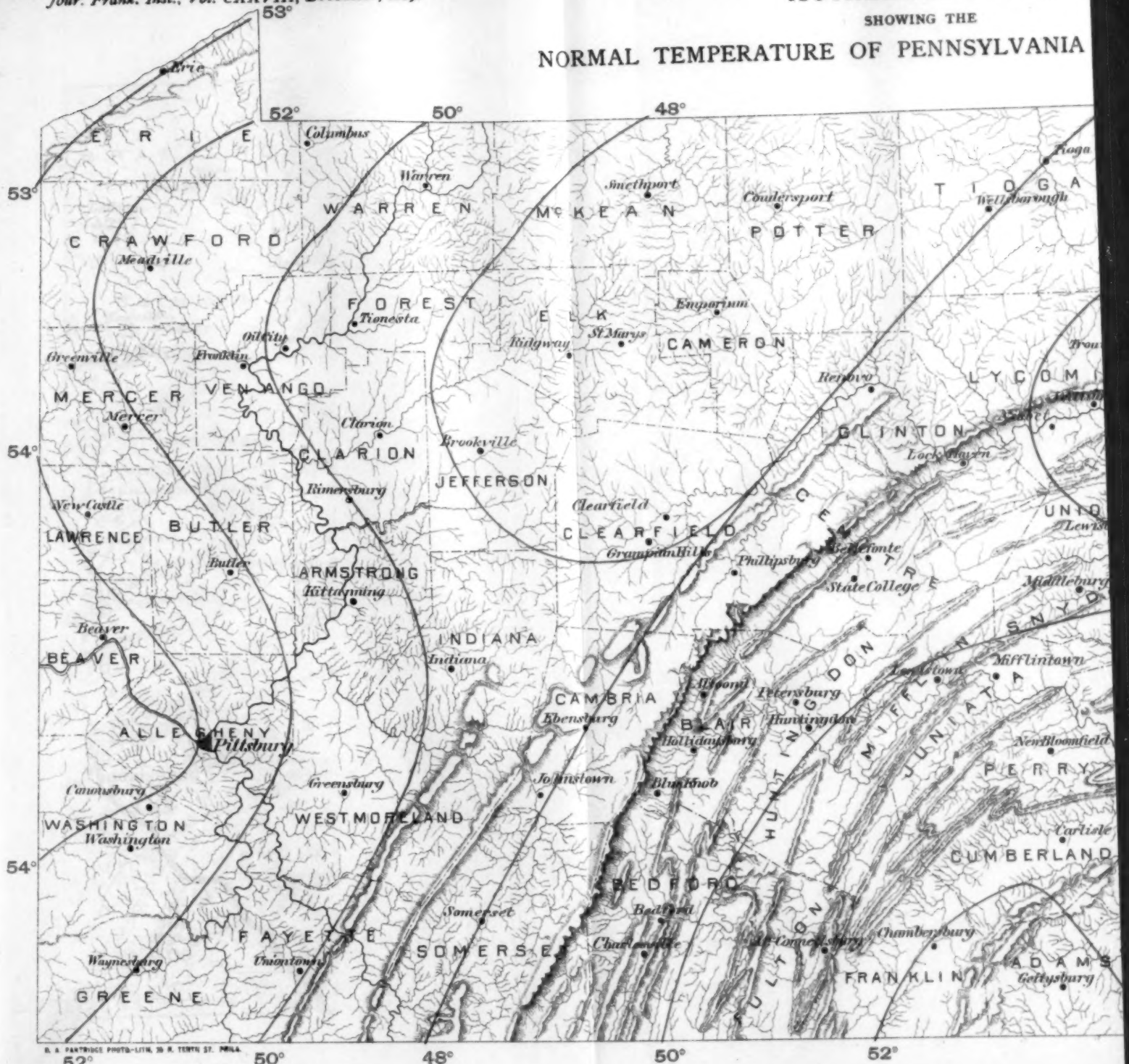
Displayman.	*Station.*
State Normal School,	Millersville.
E. C. Wagner,	Girardville.
Hartford P. Brown,	Rochester.
L. H. Grenewald,	York.
J. E. Pague,	Carlisle.
C. L. Peck,	Coudersport.
H. D. Miller,	Drifton.
Smith Curtis,	Beaver.
M. Tannehill,	Confluence.
S. C. Burkholder,	Pollock.
Robt. M. Graham,	Catawissa.
Henry F. Bitner,	Millersville.
A. J. Edelman,	Pottstown.
A. M. Wildman,	Langhorne.
N. E. Graham,	East Brady.
B. F. Gilmore,	Chambersburg.
Frank M. Morrow,	Altoona.
A. Simon's Sons,	Lock Haven.
E. W. McArthurs,	Meadville.
J. K. M. McGovern,	Lock No. 4.
Raftsman's Journal,	Clearfield.
W. S. Ravenscroft,	Hyndman.
R. C. Schmidt & Co.,	Belle Vernon.
Jesse R. Brown,	Lehmasters.
H. W. Mullen,	Centre Valley.
Mayer Bros.,	Bloomsburg.
E. C. Lorentz,	Johnstown.
W. M. James,	Ashland.
Miller & Allison,	Punxsutawney.
Dr. A. L. Runion,	Canonsburg.
E. J. Sellers,	Kutztown.



ISOTHERMAL LINES,

SHOWING THE

NORMAL TEMPERATURE OF PENNSYLVANIA



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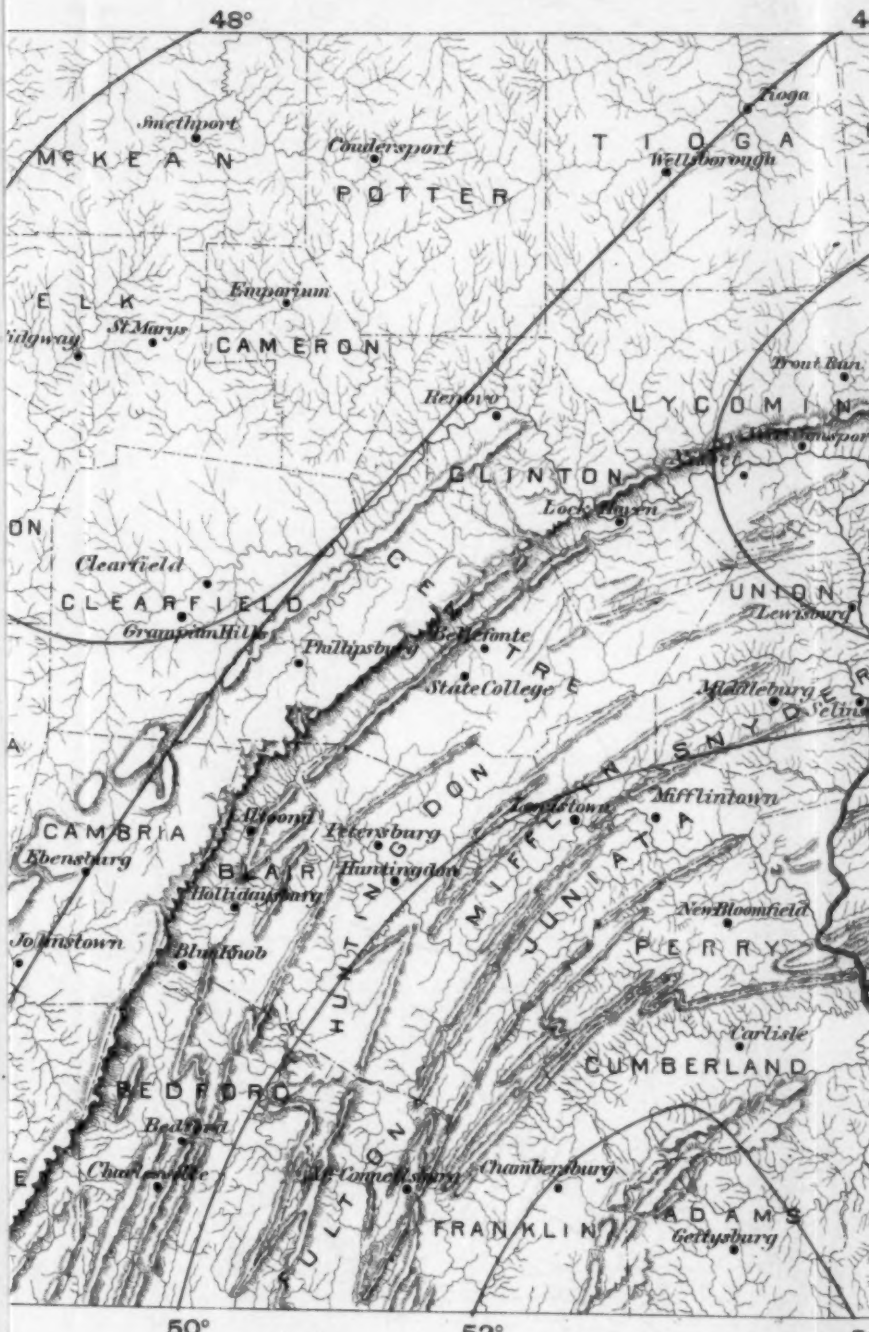
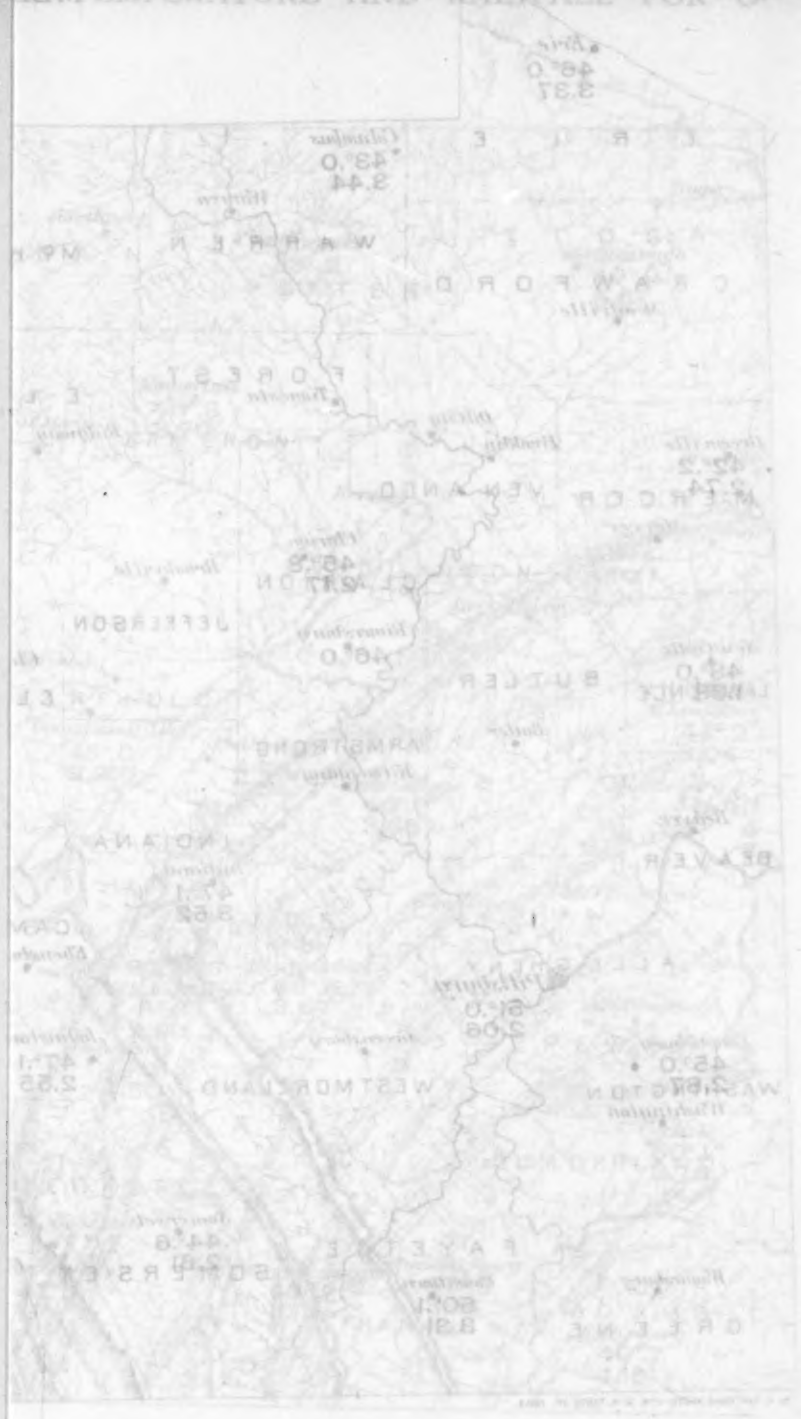


NIA FOR OCTOBER.



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3. The Board of Managers of the FRANKLIN INSTITUTE shall, before the first day of January, one thousand eight hundred and ninety, select three citizens of the United States of competent scientific ability, to whom the memoir shall be referred; and the said Judges shall examine the memoirs and report to the FRANKLIN INSTITUTE whether, in their opinion, and, if so, which of their memoirs is worthy of the Premium. And, on their report, the FRANKLIN INSTITUTE shall decide whether the Premium shall be awarded as recommended by the Judges.

4. Every memoir shall be anonymous, but shall contain some motto or sign by which it can be recognized and designated, and shall be accompanied by a sealed envelope, endorsed on the outside with some motto or sign, and containing the name and address of the author of the memoir. It shall be the duty of the Secretary of the FRANKLIN INSTITUTE to keep these envelopes securely and unopened until the Judges shall have finished their examination; when should the Judges be of opinion that any one of the memoirs is worthy of the premium, the corresponding envelope shall be opened, and the name of the author communicated to the INSTITUTE.

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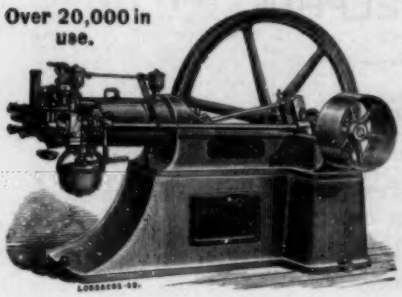

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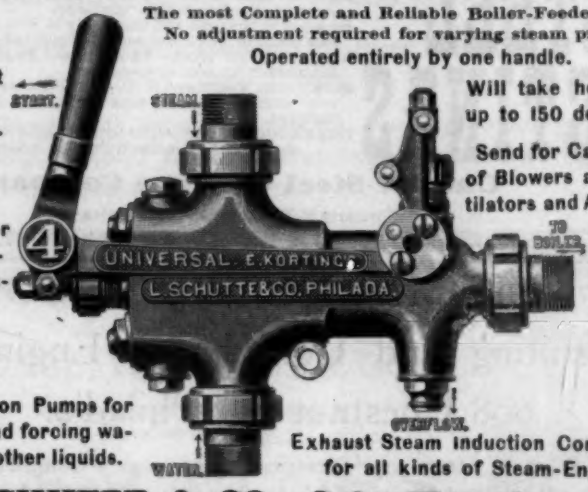

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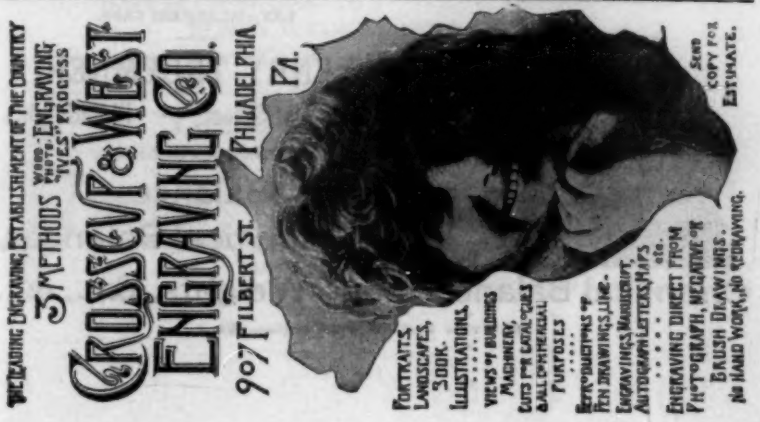
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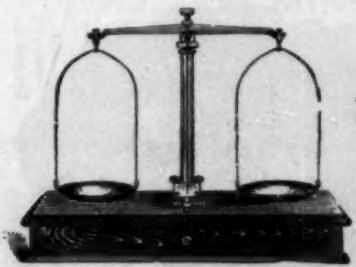

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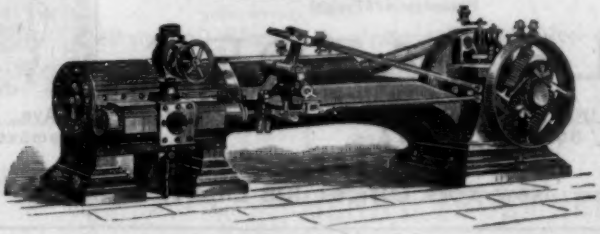
TRENTON  ENGINE

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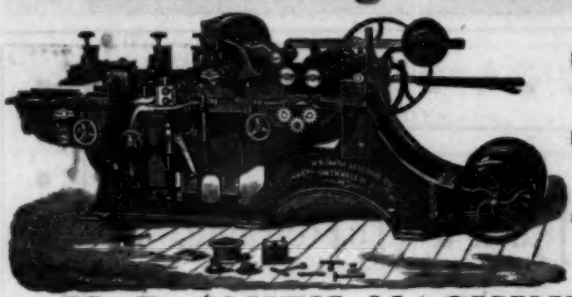

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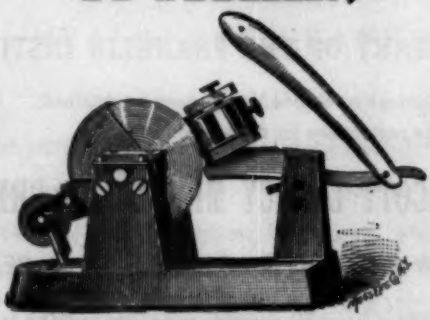

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